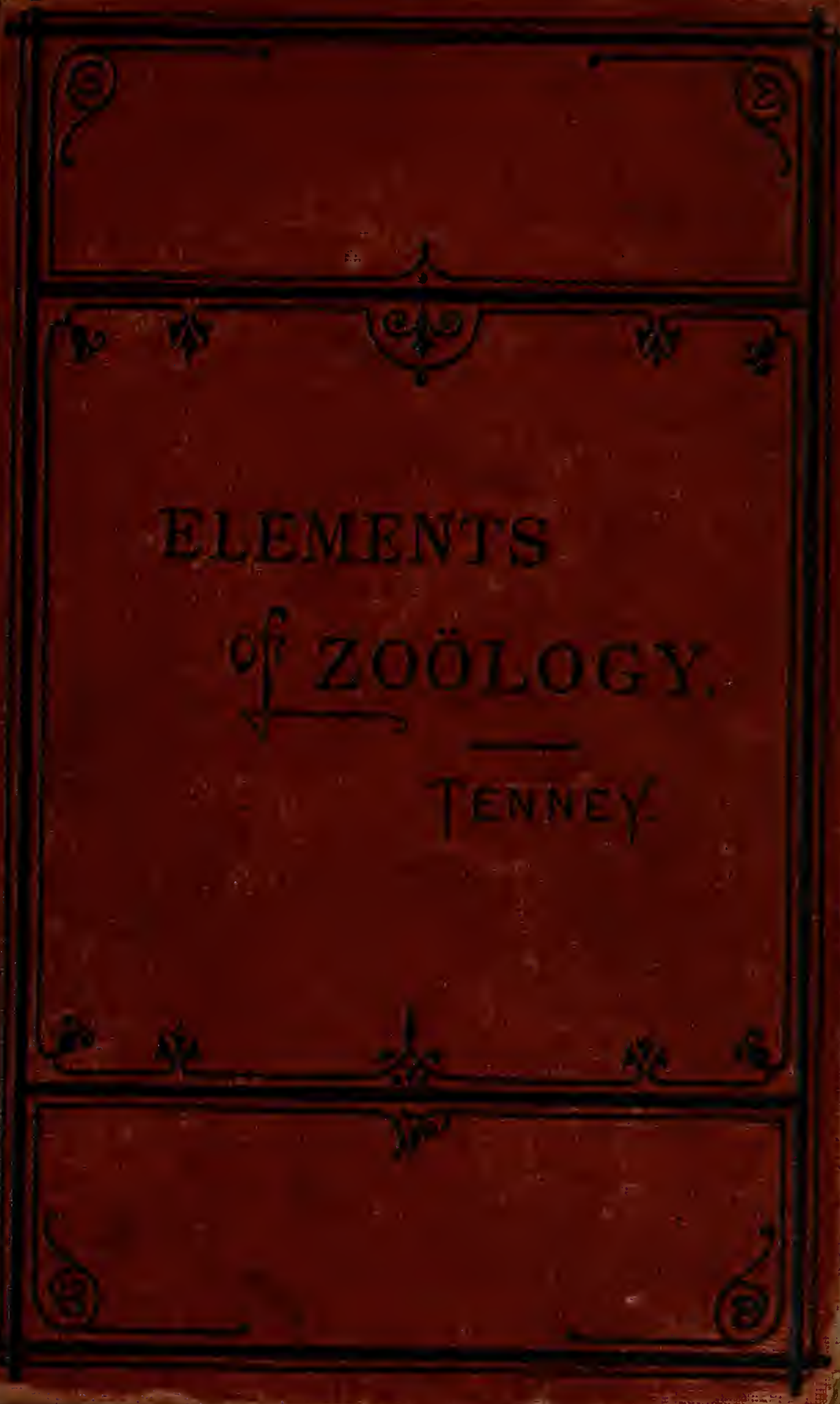

ELEMENTS of ZOÖLOGY.

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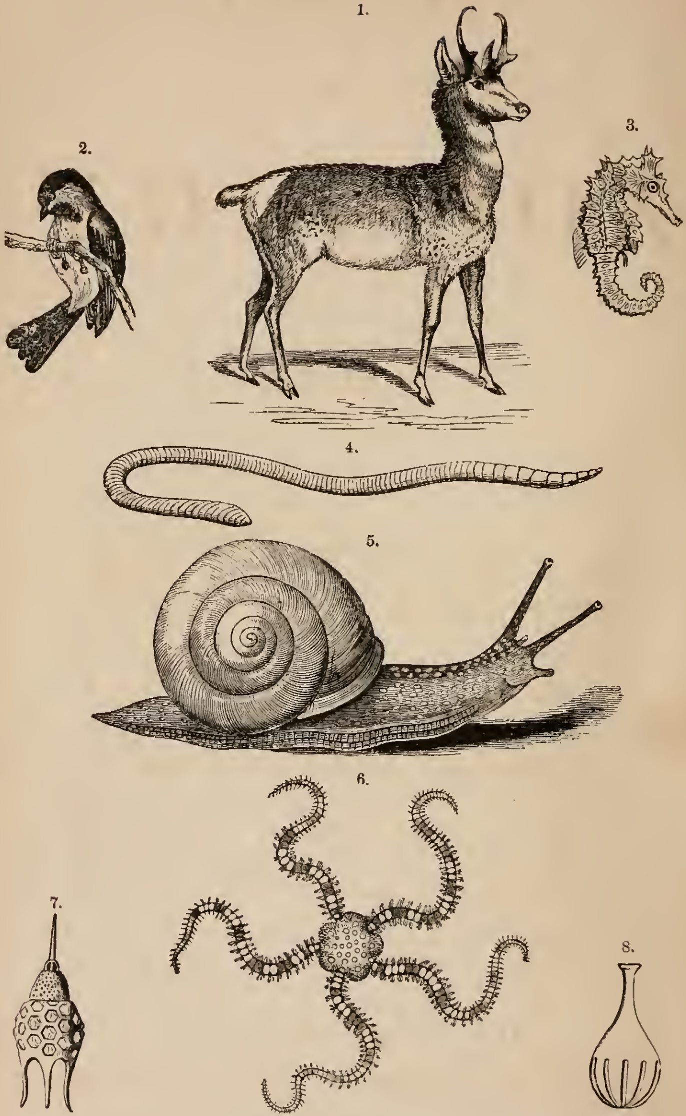

1, 2, 3, Vertebrates ; 4, An Articulate ; 5, A Mollusk ; 6, A Radiate ; 7, 8, Protozoans.

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ELEMENTS

OF

ZOÖLOGY.

A TEXT-BOOK.

BY

SANBORN TENNEY, A.M.,

PROFESSOR OF NATURAL HISTORY IN WILLIAMS COLLEGE.

ILLUSTRATED BY 750 WOOD ENGRAVINGS.

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TO

STUDENTS OF NATURAL HISTORY

THIS BOOK IS RESPECTFULLY DEDICATED BY THE

AUTHOR.

PREFACE.

This book is intended to give an outline of the Animal Kingdom, and thereby to present the elementary facts and principles of Zoölogy.

In its preparation the author has freely used all the materials at his command. He is under special obligations, however, to the writings of Agassiz, Huxley, Dana, Owen, Milne-Edwards, Siebold, Clark, Gill, Baird, Verrill, Packard, Rollestone, Flower, Woodward, Morse, Coues, Weinland, and others whose names will be found in connection with the treatment of the various subjects.

As there is not yet any universally accepted system of classification of the various forms which belong to the Animal Kingdom, the more modern systems are, in most cases, presented, and then such schemes are adopted as will, on the whole, be of the greatest aid in studying the various animal forms on the one hand, and in studying the writings of zoölogists, on the other.

No attempt is made to describe species, but the animals are described in groups. The numerous species figured. however, serve to make the student familiar with many of the leading forms in each group.

About five hundred of the wood-cut illustrations are from the author's "Manual of Zoölogy" and, in most cases, were drawn and engraved expressly for that work—a part of them from nature, and the others mainly from the special works of Cuvier, Schinz, Audubon and Bachman, Wilson, Holbrook, Storer, Dekay, Harris, Say, Sanborn, Emmons, Binney, Woodward, Gould, Lea, Conrad, Agassiz, Müller, Dana, Milne-Edwards, Verrill, Ehrenberg, Huxley, and Wood. About thirty have been drawn and engraved expressly for this book—mainly from the works of Huxley, Griffith and Henfrey, Owen, Pouchet, and Carpenter.

Many of the other illustrations are from Carpenter's "Principles of Comparative Physiology," and Carpenter's "Microscope and its Revelations;" Milne-Edwards' "Manual of Zoölogy;" Brehm's "Lehrbuch der Zoölogie;" T. Rymer Jones's "Animal Creation;" Woodward's "Recent and Fossil Shells;" and from Flower's "Osteology of the Mammalia."

About twenty of the cuts were kindly furnished by Dr. A. S. Packard, Jr., from his excellent "Guide to the Study of Insects;" and three from his paper "On the Development of Polyphemus." And about twenty are, by permission, from Professor A. E. Verrill and Professor S. I. Smith's valuable "Report upon the Invertebrates of Vineyard Sound," and Verrill's instructive paper on "External and Internal Parasites of Man and Domestic Animals."

The author is also under obligations to Professor J. D. Dana and to Messrs. Dodd & Mead, for nine illustrations from Dana's charming work on "Corals and Coral Islands;" and to Professor A. Hyatt, for one from his "Observations on the Polyzoa," and to Dr. Elliot Coues, for six from his "Key to North American Birds," and to the publishers of the "American Naturalist," for two and to the "Popular Science Monthly," for one.

The author desires to express his thanks to Dr. A. S. Packard, Jr., for information in regard to Insects and Crustaceans; and to Professor A. E. Verrill for information and suggestions in regard to Crustaceans, Worms, and Polyps.

Nor would he forget to thank his Publishers for their liberal expenditures which have enabled him to illustrate extensively every part of the work.

Williams College,
Williamstown, Mass.

July, 1875.

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CHAPTER I.

WHAT ZOÖLOGY IS

AND

A GENERAL IDEA OF THE ANIMAL KINGDOM.

In entering upon the study of any science or department of learning, it is important to understand, at the outset, what the science is, in general terms, and what is the nature of the subject or subjects of which it treats or with which it deals.

Zoölogy is the department of Natural History which treats of Animals. It is the scientific history of the Animal Kingdom as a whole, and of all the various forms of which it is composed.

Natural History, in its broadest sense, is the science which treats of the earth and of all natural objects upon its surface and within its crust. The term, however, is too often used in a restricted sense as meaning the same as Zoölogy. In addition to Zoölogy, Natural History also includes Botany, Geology, and Mineralogy.

The word Zoölogy comes from two Greek words, *zoön*, an animal, and *logos*, a discourse.

As Zoölogy treats of all animals, the lowest as well as the highest, it is important, as already stated, to know at the outset what animals are; or, in other words, to know what constitutes an animal.

While all intelligent persons recognize as animals, Man, monkeys, the beasts of the forest, the cattle and sheep of the meadows, the birds of the air, the fishes of the waters, and all other similar forms, it must here be understood that it is not easy—and perhaps not possible in the present condition of science—to state in precise terms exactly what animals are; or, in other words, to frame a definition which shall apply to all animals, to the lowest as well as to the highest forms, and which shall not apply to any of the forms of plants.

So far as regards the higher forms of animals and plants, there is little or no difficulty in defining them; but the difficulty arises when the naturalist has to deal with the lower, and especially with the microscopic forms of life.*

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* In view of the great difficulty in drawing an exact line of separation between Animals and Plants, Haeckel has recommended the recognition of an intermediate Kingdom to be called the Regnum Protisticum, in which all organisms shall be included which cannot with certainty be referred either to the Animal Kingdom on the one hand, or the Vegetable Kingdom on the other. Regnum Protisticum literally means the kingdom of simplest organisms.

As it is not yet proved that there is really any such intermediate Kingdom in nature as is here suggested, the recommendation of Haeckel cannot at present be adopted.

"Irritability, contractility, locomotion, and the 'cyclosis,' or circulation of absorbed and assimilated nutritive matters, are phenomena universal in the animal, and occasionally observable in the vegetable kingdom; whilst the secretion of chlorophyll, and of cellulose, and the power of regenerating an entire compound organism from a more or less fragmentary portion, are properties nearly, though not quite universal in vegetables, and only occasionally noticeable among animals. It may be anticipated, that in the few cases in which it may at present be difficult to decide with perfect certainty as to the animal or vegetable character of an organism, an increase in our knowledge, if not of its very simple structure, yet of its development, and if not of either its development or its structure, yet of the development and structure of forms which by gradual transitions connect it with undoubted animal or undoubted vegetable forms, is likely at some time to enable us to place it

In general terms it may be stated that *Animals are living beings which are nourished and built up wholly by organic food—that is, by vegetable and animal materials—and which have sensation and the power of voluntary motion, and which consume oxygen and give off carbonic acid.*

Plants are organisms which are endowed with life probably as real as that of animals, and perhaps differing from that of the latter only in degree; but, unlike animals, they are sustained and built up by inorganic nutriment—that is, by earthy materials, water, and gases—and they consume carbonic acid and give off oxygen.* Although it probably cannot be said that they have true sensation, they seem to have something analogous to sensation; and it is now generally maintained by botanists that all plants have spontaneous motion. Such motion, however, is in most cases too slow for our observation. Yet much has

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in one or the other of these two kingdoms of life. But it must be said that there are organisms which at one period of their life exhibit an aggregate of phenomena such as to justify us in speaking of them as animals, whilst at another they appear to be as distinctly vegetable. A monad [Page. 491] may at one period be possessed not only of a nucleus and contractile vacuole, but of a cilium, by the aid of which it swims about; at another it may have lost its cilium and effect locomotion by the protrusion of pseudopodia like an Amœba; whilst in a third it may surround itself with an envelope of cellulose. If it should prove to be true that organisms as high in the scale as the Amœbina [Fig. 746] and Actinophryna [Fig. 752], can have their development traced back to the specialization of protoplasm within vegetable cells, it would appear to be necessary to adopt a phraseology which should speak of such creatures as being at one time plants and at another animals."—Rolleston, "*Forms of Animal Life.*"

* As to the relations of oxygen and carbonic acid to living plants and animals, it must be stated here that the definitions given above have to be modified by the fact that Wöhler claims to have shown that some kinds of the Infusoria give off oxygen instead of consuming it, as is done by animals in general; and that Schlossberger and Döpping claim to have shown that some kinds of mushrooms exhale carbonic acid instead of consuming it, as is done by most species of plants.

been accomplished in the study of the movements of plants, and the whole subject of plant-motion is one of great interest, and of great importance in its scientific bearings.

The descent of the root into the earth, the ascent of the stem into the air, and the turning of the branches and leaves towards the light, observed in plants generally, are all regarded by botanists as spontaneous movements, although imperceptibly slow.

Some kinds of plants, as the Sensitive Plant (*Mimosa pudica*), exhibit a sort of sensitiveness or irritability when somewhat roughly touched, and, at such times, they suddenly change the position of their leaves or leaflets, quickly folding them more or less completely, as they do at night.

There is one kind of plant, Venus's Fly-trap (*Dionæa muscipula*), of North Carolina, which has such a degree of sensitiveness and power of rapid movement, that the moment a fly or other insect alights upon the curious appendage which each leaf bears at its summit, the "trap" closes, often capturing the insect, pressing it harder and harder the more it struggles, and thus, in many cases, depriving it of life.

As examples of rapid movements of plants which are apparently, if not really, independent of any external force or excitation, it may be mentioned that the spores of many kinds of algæ move spontaneously in the water when they are first discharged from the parent cells in which they originate, and hence they appear very much like minute infusorial animalcules. The movements are made by means of exceedingly minute hair-like appendages or cilia, having the closest resemblance to the vibratile cilia of infusoria. Again, many kinds of microscopic algæ, well known under the name of Desmids and Diatoms (Fig. 2[5]), move freely about in the water, even in their adult state. And, as an example of flowering plants which apparently exhibit spontaneous movements, we may mention the *Desmodium gyrans* of the East Indies, a leguminous plant, with trifoliate leaves, which has the two lateral leaflets continually rising and falling, by a succession of jerks; *and one leaf rises while the other falls!*

In view of the facts now stated as modifying the definitions of animals and plants, as given above, it appears that if we would give definitions to which there are no exceptions, we can hardly say more than that Animals are living beings which are nourished and built up wholly by organic food; and that Plants are living organisms whose nourishment is derived directly from inorganic materials.

And it may be stated here that it is one of the chief provinces of the vegetable kingdom to convert mineral or inorganic substances into food upon which animals can subsist.

As to modes of reproduction, it may be stated, in general terms, that animals are developed from eggs or something equivalent to eggs; plants from seeds or something nearly or quite equivalent to seeds; and that the mode of development, and the extent to which it goes on, are regarded as essentially different in the two cases.

Animals, as already indicated, are of all forms and grades, from shapeless particles scarcely bearing the evidences of life, and from those that so closely resemble plants that even naturalists are sometimes in doubt whether to call them plants or animals, up to the perfect form and high rank of Man, the highest representative of the animal kingdom.

The Animal Kingdom embraces all the various forms of animal life, just as the vegetable kingdom includes all plants, and the mineral kingdom all rocks and minerals.

Animals are of all sizes, from those so minute that the human eye cannot detect them without the aid of the most powerful microscope, up to those of massive proportions, as the elephant and the whale.

Animals, in some form, are found almost everywhere. They inhabit every mountain, valley, and plain, every forest, meadow, and field, every pool, bog, and marsh, every stream, pond, and lake, the shores and shallows, and even the profound depths of the sea, and every tree, flower, fern, moss, lichen and fungus; and, in many places, every drop of water teems with animal forms.

Zoölogy treats of animals in respect to their form and structure, development, habits, name, classification, and their geographical distribution. It also treats of them in the relations which they sustain to Man, to one another, and to the vegetable kingdom.

This science has been established and brought to its present high state of perfection through the labors of such masters as Aristotle, Linnæus, Cuvier, Agassiz, and many others scarcely less renowned.

Zoölogy is a science of the highest importance, not only on account of its relations to our material welfare, and its relations to other sciences, especially to that of Geology, but, above all, as an educational branch of study.

The objects with which this science deals hold the most direct relations both to our wants and to our luxuries.

No small part of our food comes directly from the animals of the fields, the forests, the ocean, the lakes, and the streams. And the hat on our head, the coat on our back, and the boots on our feet, also come to us from the animal kingdom. And from the same source come the costly shawl, the rich furs, and the elegant silks, satins, and velvets of a lady's wardrobe. And from this source, also, come rich dyes, valuable varnishes, all of the ivory, the pearls, the mother-of-pearl, and many other things which contribute to the comforts and the luxuries of civilized man.

But while many kinds of animals yield us only benefits, many others, especially of the insect tribes, do us only harm, destroying our forests, shade-trees and fruit-trees, the crops of the field, orchard and garden, our choice shrubs and beautiful flowers, our furs, clothing and carpets, and many other articles of the household.

Zoölogy informs us what animals are useful to man, and what ones are his natural enemies; it informs us, therefore, what animals should be carefully protected and preserved, and what ones should be destroyed. And it makes known to us the habits of animals, thereby enabling us the better to avail ourselves of the benefits to be derived from those that are useful, and the better to meet and withstand the ravages of those which are injurious.

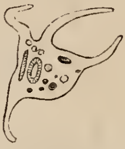
As intimated above, Zoölogy also holds direct and important relations to the science of Geology. The rocks in many regions of our country and of other countries contain vast numbers of plants and animals that lived many thousands, and in many cases millions of years ago. And these fossil plants and animals in the rocks are among the most important aids to the geologist in enabling him to trace out the different rock formations, and to find the coal and other materials essential to supply the wants of civilized man; and they are the absolutely essential aids in enabling him to read and understand the past history of our globe.

But the fossil animals can be understood only when studied by the aid of the facts and principles of Zoölogy. And therefore this science is one of the aids upon which the geologist constantly relies, well knowing that without this aid he makes little or no sure progress.

Especially is the science of Zoölogy important as an educational branch, securing to its true and faithful votaries a spirit of earnest inquiry, habits of patient and accurate observation, careful comparison, vigorous and logical thought, and power of broad generalization; and dealing, as it does, with the highest expressions of matter and of life, its study is eminently adapted to enlarge our ideas of creation, and of the Great Author of Nature. It reveals the plan which the Creator has made and carried out in the highest department of nature—the Animal Kingdom.

As already stated, some kinds of animals are exceedingly simple—so simple, that they have the animal characteristics only in the feeblest degree. The Amœba (Fig. 1 and fig. 2[6]) for example, a microscopic form found in pools and ponds, has neither mouth nor stomach, nor organs of any kind. It is indeed an animal without definite form or structure, and is, essentially, a mere particle of slime-like or mucous matter, or *sarcode*, as such structureless animal matter is called. One part is essentially the same as any other. To no particular part or parts is assigned a special function; but the functions of sensation, voluntary motion, and of nutrition, are apparently exercised by one part as much as another. On coming to a particle upon which it would feed, the Amœba envelops and digests it, any part of the animal performing the functions of tentacles, mouth, or stomach, as occasion requires.*

Fig. 1.



Amœba radiosa.—Magnified over 100 diameters.

A vast number of kinds of animals have no more or higher animal characteristics than the Amœba has. Some of these low forms, highly magnified, are shown in the accompanying wood-cut (Fig. 2).

But going upward in the scale of animal life, we find the structure more and more complex, according as the animal is higher in rank, till in those animals which may properly be called the higher forms, we find an exceeding-

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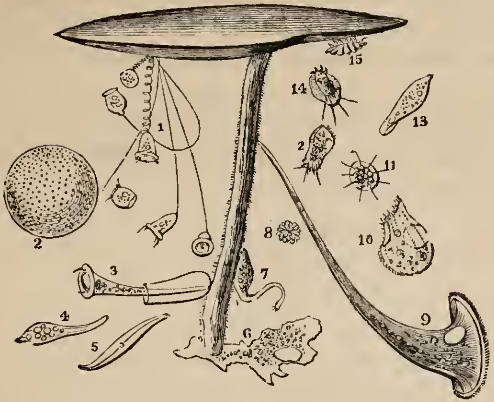
* It must be stated here that Professor H. J. Clark ("Mind in Nature," p. 10) found the Amœba invariably progressing with a certain part of the body, forward; and he called this part the head.

FIG. 2.



A leaf of Duck-weed (*a*), much magnified, and fifteen microscopic organisms—plants and animals—highly magnified.

1. *Vorticella convallaria.*
2. *Volvox globator* (a plant).
3. *Vaginicola crystallina.*
4. *Amphileptus fasciola.*
5. *Navicula hippocampus* (a plant).
6. *Amœba diffluens.*
7. *Trachelocerca olor.*
8. *Polytoma uvella.*
9. *Stentor polymorphus.*
10. *Bursaria truncatella.*
11. *Pandorina morum.*
12. *Stylonichia mytilus.*
13. *Paramecium aurelia.*
14. *Euplotes truncatus.*
15. *E. striatus.*

ly complicated structure, and each of the many functions performed by an appropriate set of organs. Such animals not only have organs by which to secure food, but also a stomach and other requisite organs to digest the food, and to change it into blood; vessels called arteries, capillaries, and veins, in which the blood circulates in all parts of the body, and thus nourishes every part; a heart to propel the blood; lungs or gills, to perform the functions of respiration, by which the blood is purified; glands, to form the various kinds of secretions; organs of excretion, to rid the body of waste material; muscles, and a skeleton to move the parts of the body, and by means of which locomotion is effected; organs for the purposes of reproduction; a complicated nervous system to supply the motive power, and by means of which the animal is endowed with special and acute senses, as those of *sight*, *hearing*, *smell*, *taste*, and *touch*.

Those animals, then, which exhibit the animal structure and functions in their higher form, have the following systems of organs, viz.:

1. *Digestive system.*
2. *Absorbent* "
3. *Circulatory* "
4. *Respiratory* "
5. *Secretory* "
6. *Excretory* "
7. *Motatory* "
8. *Reproductive* "
9. *Nervous* "

and each of these systems of organs, as stated above, performs its own peculiar and appropriate functions.

The functions of animals are of two classes, those of organic or vegetative life, and those of animal life.

The functions of Vegetative life are those of nutrition in its largest sense, and of reproduction—nutrition itself including not only digestion, but also circulation, respiration, etc. These are the functions which maintain life, and secure the growth and multiplication of organized beings; and they are common to both plants and animals.*

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* If we enumerate all the separate acts of which the function of nutrition consists, and by which it is directly and indirectly carried on, we must mention at least absorption, digestion, circulation, respiration, exhalation, secretion, excretion, and assimilation. Each of these acts must here be briefly described.

Absorption, in general terms, is the faculty or act by which organisms imbibe into their tissues the fluids which surround them, or which are contain-

The functions of Animal life are those of sensation and voluntary motion, as already indicated—functions which are generally regarded as belonging exclusively to animals, and which bring them into relation with the objects about them and with one another, and hence are sometimes called the functions of relation.

As regards the substance of animals, it may be stated in general terms, that all parts of their bodies, the hard parts as well as the soft, are made up of *tissues*,—and it may be added here that the same is true of plants. Thus, bones,

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ed in the cavities of their bodies. By absorption, plants secure the material necessary for their nourishment. Animals, on the contrary, especially the higher animals, receive from without only a small portion of their nourishment in this way; but most of their nourishing material is, previous to its absorption, elaborated by the digestive process. If we would prove the fact of absorption in animals, we may place a frog in water, and observe that his weight is soon thereby increased, and this, too, even when it is so arranged that no water enters the mouth. If water be introduced into the stomach of any living animal, and both orifices of the organ closed, even then the water will disappear, being absorbed by the walls of the stomach, whence it goes to mingle with the blood. But the true *Absorbent system*, by which the nutritive products of digestion are secured to the blood, is described on page 43.

Digestion, circulation, and respiration, have, for the present, been sufficiently noticed on page 9. These acts or processes will be more fully explained farther on.

Exhalation is the escape of useless substances through the external and internal surfaces of the animal—an act depending upon the permeability of the animal tissues.

Secretion is a function by which certain substances are selected and eliminated from the blood by special organs called glands. Saliva is secreted by the salivary glands; bile is secreted by a glandular organ called the liver; urine is secreted by the kidneys, and so on.

All the functions and organs by which the animal is freed of the waste products of the body, are often spoken of as the functions and organs of *Excretion*. The skin, the lungs, and the bladder, are excretory organs, and perform excretory functions.

Assimilation is the act by which the tissues are built up from the material furnished by the blood, and by which they are sustained in strength and in growth, and by which, in many cases, they are restored when destroyed.

membranes, cartilages, ligaments, muscles, tendons, nerves, etc., are tissues of the animal body.

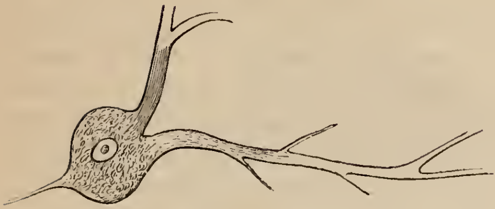
.Through researches made by the aid of the microscope, it has been ascertained that all animal and vegetable tissues are made up of *cells*, the cells in most cases being more or less modified, according to the nature of the part of the organism. Nay, in a vast majority of cases they are so exceedingly modified, that to the uninstructed eye they present little or nothing of their fundamental form and structure.

Cells then, or something nearly or quite equivalent to them, are the ultimate structural elements of the animal or vegetable body, as far as the subject is now understood. That is, when the animal or vegetable body is analyzed to the last degree—as to the structure of its various parts—the microscopist comes to the cell, more or less modified, as the final limit of his analysis (Figs. 3–11).

A living, active cell, in its simplest form, is an exceedingly minute vesicle or sac, filled with a more or less viscid liquid named protoplasm—from *protos*, first, and *plasma*, from *plasso*, to form ; within the sac there is a central particle or portion called the nucleus, and within the nucleus there is, in many cases, a still smaller particle called the nucleolus. In many cases there are two or more nuclei in a cell (Figs. 5, 7, 8). In the liquid of the cell there are often seen many minute granules and globules, besides the nucleus. As to the sac itself, or cell-wall, it must here be stated that it has no structure, so far as is known ; that is, it is structureless. Chemically considered, the cell-wall in animals consists of a nitrogenous compound ; in plants, it consists of the substance called cellulose, and is composed of carbon, hydrogen, and oxygen.

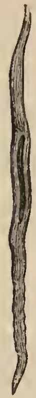
It should be remarked here that while our general state-

FIG. 3.



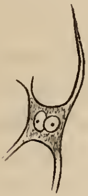
A large branching cell from the gray cortical layer of the human cerebellum, showing nucleus and nucleolus. Magnified 350 diameters.

FIG. 4.



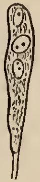
Muscular fiber-cell from a human artery. Magnified 350 diameters.

FIG. 5.



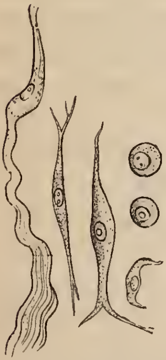
Cell with two nuclei, each with a nucleolus, from the spinal cord of Man. Magnified 350 diam.

FIG. 6.



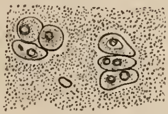
Ivory cells from the tooth of a Dog. Magnified 350 diameters.

FIG. 7.



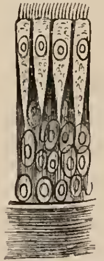
Formation of Connective tissue from cells. Magnified 100 diameters.

FIG. 8.



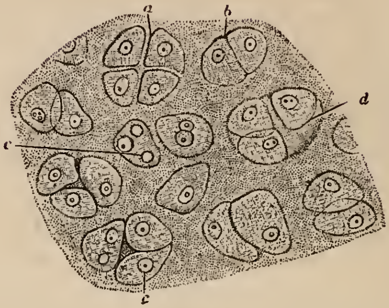
Cartilage of the human rib. Nucleated cells forming in the structureless matrix, some of the cells having two nuclei. Magnified 100 diameters.

FIG. 9.


Cilia.
Full grown cells.
Intermediate layers of cells.
Layers of young unmodified cells.
Basement layer.
Elastic fibers.

Epithelial cells from the human trachea. Magnified 350 diameters.

FIG. 10.



Branchial cartilage from a Tadpole, showing cells in various phases. *a*, four cells, formed by the division and subdivision of one parent cell; *b*, pair of cells in apposition; *c*, nuclei; *d*, cavity with three cells. Magnified about 350 diameters.

ment made above is true, that animals are made up of tissues, *there are some kinds of animals so simple that a single cell constitutes the whole animal.* And the same is true of some kinds of plants. That is, there are unicellular animals, and unicellular plants * (Fig. 11).

Nay, we must go a step farther, and say that microscopists have shown that the simplest or lowest animals and plants are merely nucleated particles of protoplasm, these particles not even having a cell-wall—that is, they are not inclosed in a sac; and that some kinds are so simple that the particles are not even nucleated.

And further, it is pretty clearly demonstrated that all animals, even the highest forms, begin their embryonic existence as mere particles or aggregated particles of protoplasm, and that out of this "primitive indifferent tissue," as it has been called, all the cells and tissues, and parts of the animal body are evolved.

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* Botanists describe the vegetable cell as consisting of—first, a membrane or *permanent cell-wall*; second, of a delicate mucilaginous film lining this wall, and called by Mohl the *primordial utricle*; third, of a more or less soft or gelatinous body in the center of the cell, and called the *nucleus*; and fourth, of a viscid liquid called *protoplasm*, which often has an abundance

The egg or ovum of all animals, even of the highest, is essentially a cell, and may be taken as the type of all cells. From this cell all the other cells and parts of the animal body are developed; the peculiar process called segmentation of the yolk being the beginning of the formation of new cells within the parent cell or ovum.

It must be added here, however, that at its very beginning the ovum or egg itself is something even much simpler than a cell, being merely a minute particle of fluid matter, that is, mere protoplasm.

Animals and plants are called Organic bodies or Organized beings, because they are made up of tissues, as explained above; while all mineral substances—as crystals, earth, water, and gases—are called Inorganic bodies, because they have not this structure.

Chemically speaking, it may be stated in general terms that animal tissues are mainly composed of carbon, hydrogen, oxygen and nitrogen; while the first three elements,

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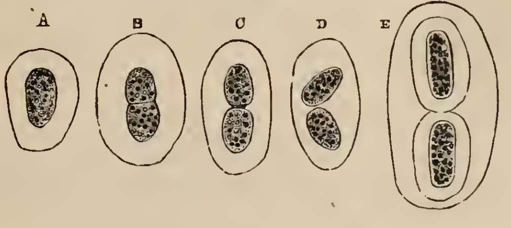
of small granules floating in it, and which fills the space between the nucleus and the lining membrane or primordial utricle, already mentioned.—See Gray's Structural and Systematic Botany.

FIG. 11.



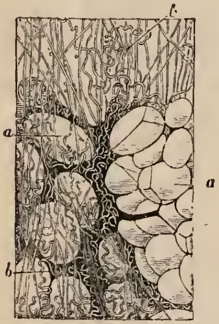
Various phases of the development of a unicellular plant, *Palmoglœa macrococca*; a plant which spreads as a green slime over damp walls, etc. A, a full-grown cell; B, C, D, E, successive stages of one cell dividing into two.

namely, carbon, hydrogen, and oxygen, are the chemical elements which make up the vegetable tissues. This is true only as a general statement, and for the higher forms; the lowest forms of both animals and plants in many cases are composed of the same chemical compounds, differing only, or mainly, in degree.

Although there are, apparently, many sorts of tissues in the animal structure, and although various names are given to the different forms under which the tissues appear, they are really only modifications of a few distinct kinds, such as the Cellular or Connective, the Muscular, and the Nervous.

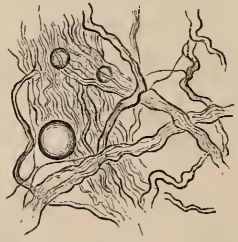
Cellular tissue—also better called Connective, Areolar, and Fibrous tissue—is composed of filaments variously interlaced, and small plates or layers irregularly united, thus leaving spaces or cavities between them. This tissue is the most abundant of all the materials of the body. It

FIG. 12.



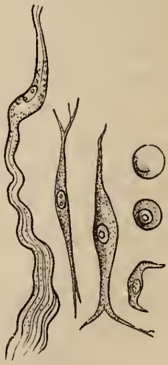
Fat-cells in Cellular or Connective or Areolar tissue; *a*, fat-cells; *b*, fibers of areolar tissue. Highly magnified.

FIG. 13.



Cellular or Connective or Areolar tissue, with fat-cells. Human. Magnified 100 diameters.

FIG. 14.



Formation of Cellular or Areolar tissue, from cells. Magnified 100 diameters.

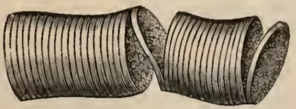
forms the whole substance of the lowest animals, and in the higher animals it not only connects as well as separates organs, but also enters largely into their structure. It is this tissue which forms mainly the skin, and also the mucous and other membranes of the animal body. It ensheathes the muscles and the bones, and is the tissue in which gelatine is accumulated for the formation of the cartilages, and the mineral substances for the formation of the bones themselves; and it constitutes almost the whole substance of the ligaments and tendons; and it is among its meshes that the fat of the body is accumulated (Fig. 12). In a word, it has been shown by anatomists that so completely does this cellular or connective tissue invest and enter into all the organs of the body, even of the highest animals, that if all the other tissues could be removed without disturbing this one, a perfect model of all the organs would be left, composed of this tissue alone!

Muscular tissue constitutes the part of the animal body which is called the flesh or muscles—that is, the parts familiar to every one as lean meat. This tissue is composed of fibers which have the property of contraction.

There are two principal kinds of muscle—the striated and the unstriated muscle.

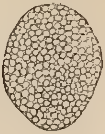
Striated muscle includes all the ordinary muscles of the trunk and limbs of the Vertebrate animals. It consists of bundles of fibers, each bundle of which is made up of smaller bundles, and so on, until the

FIG. 15.



Primitive bundle of muscle magnified 350 diameters, partly separated into disks.

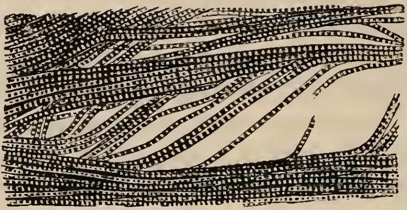
FIG. 16.



End view of Fig. 15, more magnified.

primitive bundle is reached, and that is made up of microscopic fibers termed fibrillæ. Each primitive bundle is enveloped in a strong, elastic membrane or sheath, called the sarcolemma. When the sarcolemma is torn, the fiber divides into thin minute fibrillæ, or more rarely breaks into disks, as seen in Fig. 15. Each one of the fibrillæ presents dark and light parts alternating regularly with each other, and corresponding exactly with the distances of the transverse striæ on the entire fiber itself.

FIG. 17.



Striated muscular fiber separating into fibrillæ. Magnified.

As already indicated on the 17th page, the bundles of fibers mentioned above are all enveloped in and bound together by connective tissue, which, at the same time, supports all the vessels and nerves of the muscle, and which, in some cases, also extends in the form of a sheath or fascia, over the whole.

Unstriated muscle consists of elongated band-like fibers, often called fiber-cells, each of which has an elongated nucleus. These fibers are without striæ and they have no sarcolemma, and they do not break up into fibrillæ. These fibers are most abundant in the hollow viscera, such as the stomach, intestines, bladder, etc.; but they also occur in the arteries, veins, etc.

Nervous tissue is soft and generally whitish in color. It constitutes the brain, spinal cord, and all the nerves, and is the seat of sensation.

As already stated, the kinds of animals are exceedingly numerous. The number of kinds is not known, but may be safely estimated as high as a million, or even higher; the small and microscopic, however, comprise an immense majority of the whole number.

If, in order to become acquainted with the Animal Kingdom, it were necessary to study all the kinds of animals, one by one, a life-time would be much too short to gain a knowledge of the subject. But it is an interesting and encouraging fact, that the Animal Kingdom has been so constructed by the Creator, that, by the thorough study of a few animals, we may learn the most important facts and principles concerning all animals.

And *it is absolutely essential* for the student of Zoölogy *to become thoroughly acquainted with a few of the typical forms of animals, by studying the animals themselves*, if he would have any clear and definite conception of the Animal Kingdom, and of Zoölogy as a science.

Ever since men began to study animals, they have endeavored to classify them. That is, they have endeavored to observe how the different kinds are related to one another, and to express that relation in written language. And it may be stated here, that the investigation of the true relations or affinities of animals with one another, is one of the highest departments of study connected with the science of Zoölogy. And, as one of the results of this sort of study, naturalists have learned that the Animal Kingdom may be divided into more or less distinctly-marked roups. These groups have been named

BRANCHES,
CLASSES,
ORDERS,
FAMILIES,
GENERA,
and SPECIES.

That is, the Animal Kingdom is divided into Branches, each branch into Classes, each class into Orders, each order into Families, each family into Genera, and each genus into Species composed of individuals essentially alike.

These groups must not be regarded as mere artificial contrivances; on the contrary, they rest on a natural basis. And, according to Agassiz:

> Branches are characterized by plan of structure.
>
> Classes, by the manner in which the plan is executed, as far as ways and means are concerned.
>
> Orders, by the complication of structure.
>
> Families, by form, as determined by structure.
>
> Genera, by details of execution in special parts.
>
> Species, by the relation of individuals to one another, as well as by the proportion of their parts, their ornamentation, etc.

That is, according to this view, certain characters determine the Branch, certain others the Class, others the Order, others the Family, others the Genus, and others still the Species.

These principles of classification, however, are not universally recognized and fully applied; but most, or many naturalists designate at least the subordinate groups by a combination of characteristics more or less different from one another in their nature.

But it must be stated here that all scientific classification of animals is based essentially upon structure—upon structure, and upon form as determined by structure. This is strictly true unless we find an exception in the fact that, in deciding upon species, we must also consider size and color.

As a simple illustration of the natural groups of animals enumerated above, it may be stated that:—

All animals which have a back-bone constitute one Branch called the Vertebrates;

All of the back-boned animals which are covered with feathers, and organized for flight, constitute one Class, called the Birds;

All birds which are specially fitted by their structure and form for capturing other birds and quadrupeds for food, constitute one Order, called the Raptores or Birds of Prey;

All birds of prey which have the head covered with feathers, and the eyes on the sides of the head, and more or less sunken, constitute one Family, called the Falconidæ;

All of the members of the Falcon Family which have the bill short, and strongly curved from the base to the tip, and which have a distinct horny tooth in each side of the upper mandible, constitute one Genus, the true Falcons;

All the members of the genus of Falcons, which are essentially like our common Duck Hawk (*Falco anatum*), constitute one Species; all that are essentially like our common Sparrow Hawk (*Falco sparverius*), constitute another species; and so on.*

Other Branches, Classes, Orders, etc., of the Animal Kingdom are formed in a similar manner.

Cuvier recognized four great Branches or Types in the Animal Kingdom—the Vertebrata, the Articulata, the Mollusca, and the Radiata. Most—or at least, many—naturalists of the present day recognize, in addition to these, a fifth group, called the Protozoa, including a vast number of small, minute, and microscopic organisms, together with the sponges. So that the great Branches or Types —or Sub-kingdoms—of the Animal Kingdom are:—

---

* The question, "What is a species?" has never been answered to the entire satisfaction of all naturalists. But practically we may refer to a given species all those individuals that are essentially alike; so essentially alike that there is sufficient evidence for believing that they have descended from one pair or a common ancestry.

The doctrine held by many distinguished naturalists—that in a certain sense *all* animals have had a common origin, that is, that our present "species" have been evolved from other and earlier species, and the latter from still earlier species, and that in the beginning of life on the globe there were only a few simple forms, and probably only one simple form—cannot be dwelt upon here. For the views of these naturalists, as to the "Origin of Species," and as to the doctrine of "Evolution," see the writings of Darwin, Huxley, Mivart, Cope, Hyatt, Gill, and others.

I. VERTEBRATA,

Including all animals which have an internal jointed skeleton, and a brain and spinal cord along the dorsal side; as Man and other Mammals, Birds, Reptiles, Batrachians, and Fishes.

II. ARTICULATA,

Embracing all animals which have the body made up of a series of rings or joints, with the hard parts, when present, outside, and the nervous centers mainly on the ventral side; as Insects, Lobsters, Worms, etc.

III. MOLLUSCA,

Comprising all animals which have a soft body inclosed in a muscular sac, with or without a shell, and which are neither jointed nor radiated in their structure; as Cuttle-Fishes, and Squids, Snails, Clams, Oysters, etc.

IV. RADIATA,

Including all animals which have a radiated or star-shaped structure; as Star-Fishes, Jelly-Fishes, Sea-Anemones, etc.

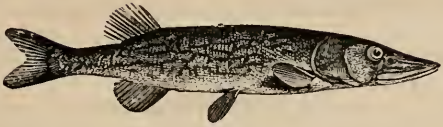
V. PROTOZOA,

Including all animals which are not constructed according to the plan exemplified in any of the four preceding branches; as Infusoria, Sponges, and Rhizopods.

Of the five great Branches enumerated above, the Protozoans are the lowest, and the Vertebrates the highest. Of the four besides the Protozoans, the Radiates are the lowest. As to the two groups Mollusks and Articulates, it is not easy to say which, on the whole, is the higher; although the higher rank is generally accorded to the Articulates.

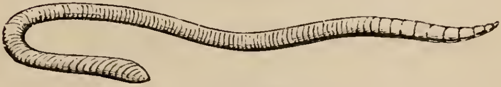
In order to express the relations of these great groups,

FIG. 18.



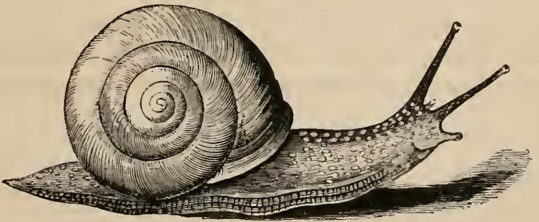
A Vertebrate.

FIG. 19.



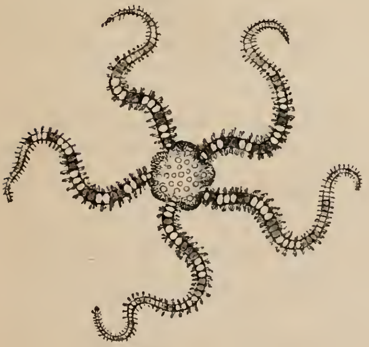
An Articulate.

FIG. 20.



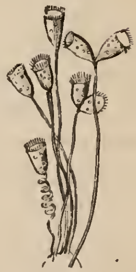
A Mollusk.

FIG. 21.



A Radiate.

FIG. 22.



A Protozoan.

as regards their higher and lower rank, some naturalists write their names thus:

VERTEBRATA.
ARTICULATA. MOLLUSCA.
RADIATA.
PROTOZOA.

And here a word of explanation is due in regard to the rank of animals. In one sense, all animals are alike perfect. Each is perfectly adapted to fulfill its own peculiar office in the economy of nature. In this sense, every animal is perfect. But in regard to organization there is, as already stated, every grade, from those of the most extreme simplicity, and with the most simple functions, to those of the highest possible complication, and with the most numerous, varied, and complicated functions. Now, an animal is higher according to its higher complication of structure, and hence, its more numerous and varied functions.

PRINCIPAL TOPICS CONSIDERED IN CHAPTER I.

Zoölogy defined.——Origin and meaning of the name.——Forms which all recognize as animals.——The difficulty of defining animals.——Animals defined, in general terms.——Plants defined.——Movements of plants.——Chief province of the Vegetable Kingdom.——Mode of reproduction in animals; in plants.——Forms and grades of animals.——The Animal Kingdom.——Animals of all sizes.——Animals found almost everywhere.——Zoölogy treats of form, structure, development, etc. ——This science established by Aristotle, Linnæus, and Cuvier.——Zoölogy a science of the highest importance.——The relations which animals hold to Man. ——Zoölogy in its relations to Man.——Relations of Zoölogy to Geology.——Zoölogy as an educational branch.——Lower and higher forms of animals.——Systems of organs in the higher animals.——Functions of animals considered.——Animals and plants composed of tissues.——Tissues made up of cells.——Cells defined.——Some kinds of animals only simple cells.——The lowest animals even simpler than a cell.——Protoplasm.——The egg essentially a cell.——Organic, and Inorganic bodies.——Chemical composition of animal tissues; of plant tissues. ——Kinds of animal tissues.——Cellular tissue.——Muscular tissue.——Kinds of muscle.——Striated muscle.——Unstriated muscle.——Nervous tissue.——Number of kinds of animals.——Impossible to study all kinds of animals one by one.——The most important facts and principles of Zoölogy learned by the study of a few kinds of animals.——Absolutely necessary to study animals themselves.——Classification of animals.——Names of the Kinds of groups recognized.——These groups not mere artificial contrivances.——A simple illustration of the natural groups.——The four great Branches or Types of Cuvier.——The five great Branches now generally recognized.——Vertebrata.——Articulata.——Mollusca.——Radiata. ——Protozoa.——Relative rank of these Branches.——Rank of animals in general.

CHAPTER II.

THE VERTEBRATA OR VERTEBRATES.

SECTION I.

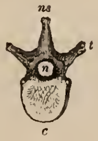
THE VERTEBRATES CONSIDERED AS A BRANCH.

As already stated on a previous page, the Branch of Vertebrates includes all animals which have an internal jointed skeleton. The form of this skeleton as it appears in Man and Birds is shown in Figs. 24 and 26.

The skeleton of the Vertebrates forms the framework of the body, and to this framework the flesh is attached, and outside of the whole is the skin, which is naked, or covered with hair, fur, wool, feathers, scales, or plates, according to the kind of animal.

The most important portion of the skeleton, or the portion which is the most constantly present, and that to which all the others are directly or indirectly attached, is the axis, called the spinal column or back-bone, at the anterior end of which is the brain-cavity or cranium. This column is made of parts called vertebræ—a single part a vertebra, from the Latin *verto*, to turn.

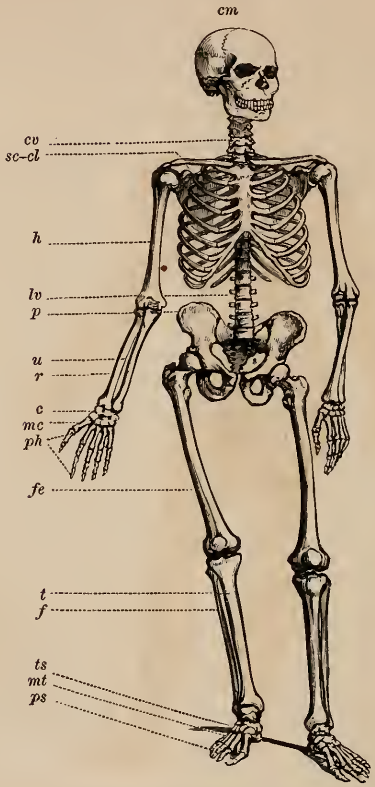
Fig. 23.



A Vertebra.

c, centrum or main body of the vertebra; *n*, neural canal; *t*, transverse process; *ns*, neural spine.

FIG. 24.

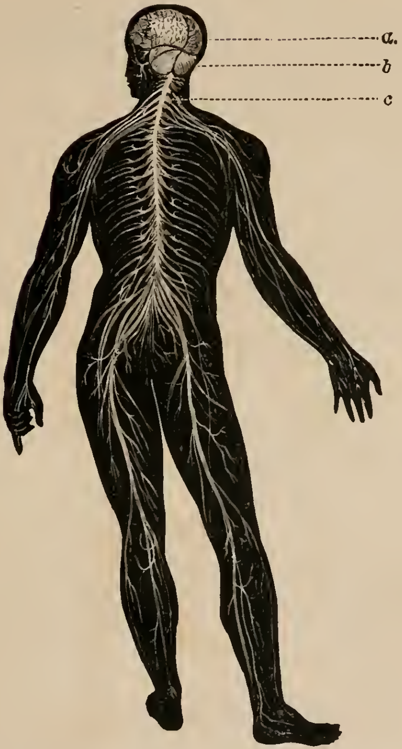


Skeleton of the highest Vertebrate—Man.

cm, cranium; *cv*, cervical vertebræ; *sc-cl*, scapula and clavicle; *h*, humerus; *lv*, lumbar vertebræ; *p*, pelvis; *s*, sacrum; *u*, ulna; *r*, radius; *c*, carpus; *mc*, metacarpus; *ph*, phalanges; *fe*, femur; *t*, tibia; *f*, fibula; *ts*, tarsus; *mt*, metatarsus; *ps*, phalanges.

Within the cranium there is an organ called the brain, from which there is a branch called the spinal cord, extending the whole length of the body, and contained in an elongated cavity or tube formed by the processes arising from the upper side of the centrums or main bodies of the vertebræ.

FIG. 25.



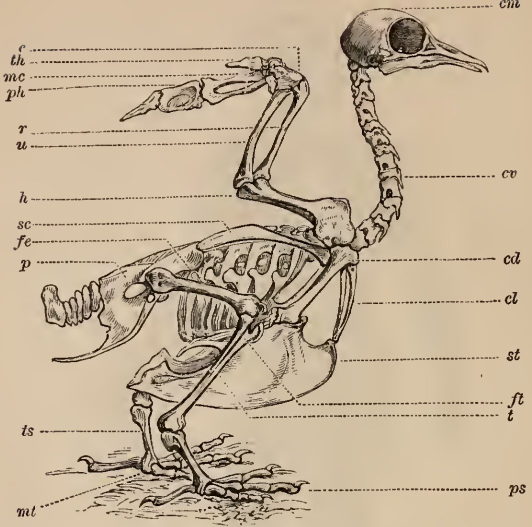
Cerebro-spinal System of the highest Vertebrate—Man.

a, cerebrum, or principal brain, called the hemispheres; *b*, cerebellum, or smaller brain; *c*, spinal cord giving off its branches of nerves.

The position of the brain has already been indicated. From the brain and spinal cord there are branches called nerves, which extend to all parts of the body.

The brain, spinal cord, and their branches, constitute the Cerebro-spinal system—the principal part of the whole Nervous system—which is much the same in its general

FIG. 26.



Skeleton of a Bird.

cm, cranium; *cv*, cervical vertebræ; *p*, pelvis; *sc*, scapula; *cl*, clavicle; *cd*, corocoid, formerly regarded as the clavicle; *st*, sternum; *h*, humerus; *u*, ulna; *r*, radius; *c*, carpus; *mc*, metacarpus; *ph* and *th*, phalanges, *th* being the thumb; *fe*, femur; *ft*, fibula and tibia, more or less united; *t*, tibia, where the fibula is no longer seen, or only faintly indicated; *ts*, tarsus; *mt*, metatarsus more or less consolidated with the tarsus; *ps*, phalanges, or bones of the toes.

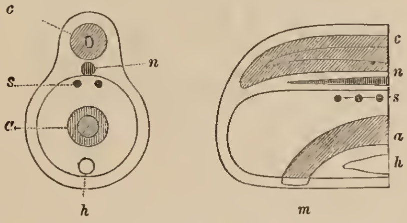
form in all the Vertebrates, differing only or mainly in degrees of development and in special characteristics. This system as it exists in the highest vertebrate—Man—is shown in Fig. 25.

Below the spinal column—before it in erect Man—there is a cavity for the heart, the organs of digestion, and other organs which perform the functions of vegetative life, that is, the functions of nutrition, etc.

Although, in defining the Vertebrates, it is sufficient, in most cases, to make special reference, as we have now done, to the spinal column and internal skeleton, it must be stated here that there are many animals belonging to this branch which have the skeleton in the condition of cartilage, as in the fishes known as sharks, skates, and sturgeons (see Figs. 301, 294, 309), and others, as the fishes known as the amphioxus, hag, etc. (see Figs. 351, 352), which have no skeleton, not even a back-bone, nor any hard parts whatever.

Therefore, to meet all cases, the Vertebrates may be defined as animals having an elongated, bony, or cartilaginous, or soft axis, with an elongated cavity or tube above this axis, containing the brain and spinal cord, and called the spinal cavity or neural canal, and a tube or elongated cavity below this axis, containing the heart, the digestive organs, and other organs of vegetative life, and sometimes called the hæmal arch or hæmal cavity—from the Gr. *haima*, blood.* So that a longitudinal, and a transverse section of any vertebrate animal, the lowest as well as the highest, are represented by the accompanying diagrams. In a word, all the Vertebrates are constructed according to

FIG. 27 FIG. 28.



A transverse, and a longitudinal section of a Vertebrate.

a, alimentary canal ; *h*, heart ; *c*, cerebro-spinal center ; *s*, sympathetic system ; *n*, notochord ; *m*, mouth.—Huxley.

---

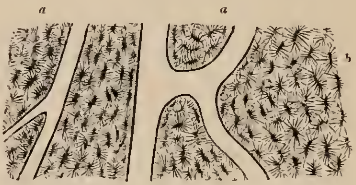
* The cavity below the axis of the body, that is, the hæmal cavity, *corresponds to the whole interior of the body of the Invertebrate animals ;* the cerebrospinal canal has no homologue, that is, it has nothing to represent it, in the Invertebrata.

one and the same *plan*—they are higher and lower expressions of one and the same style of animal architecture.

It may be added here, that in all the Vertebrata, except the amphioxus, the neural canal widens in the anterior end of the body, in accordance with the greater size of the nervous mass which it incloses.

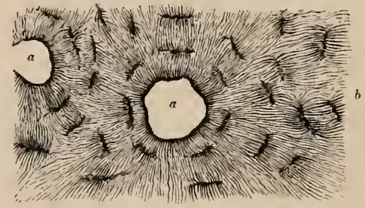
Although, as just explained, a skeleton of bony material

FIG. 29.



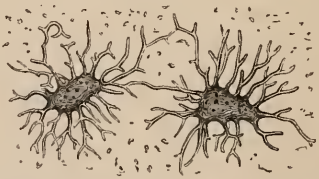
Section of a portion of the surface of the shaft of the human femur. *a*, Haversian canals; *b*, Lacunæ. Magnified 100 diameters.

FIG. 30.



Part of a transverse section of the shaft of the humerus. *a*, Haversian canals; *b*, Lacunæ, with their canaliculi. Magnified 300 diameters.

FIG. 31.



Lacunæ with the canaliculi; from the parietal bone. The dots represent the divided canaliculi, and their orifices opening into the Lacunæ. Magnified 450 diameters.

does not exist in all vertebrates, it is only in animals of this branch that true bones occur. Hard parts, it is true, exist in most or many of the animals belonging to the other great branches of the animal kingdom; but the hard parts of polyps, of star-fishes, and of sea urchins, the horny-like covering of beetles and some other kinds of insects, and the still harder covering of crabs and lobsters, the shells of snails, oysters, and clams—all are different, in very important particulars, from the bony material or hard parts of the Vertebrates.

Bones are composed of animal matter more or less extensively impregnated with earthy materials, especially with phosphate and carbonate of lime, and throughout whose substance are minute cavities called lacunæ, which send out many much more minute ramifications known as canaliculi. Most bones are traversed by a network of small canals, containing vessels which are supported by connective tissue and fatty matter; these are called Haversian canals, and they open upon the surface of the bone, and there the vessels which they contain become connected with those of the tough connective tissue which immediately invests the living bones, and which is known under the name of periosteum.

Bones, then, in the living vertebrates, we are to understand, are living and vascular animal tissues, as truly so as the flesh or any other tissues of the body, growing and changing by internal additions and modifications in essentially the same manner as the other tissues of the body grow and change, and having the same or similar powers of repairing an injury as the other tissues have.

On the contrary, the shells of snails and clams grow and change only by additions to and modifications of the circumference; and, if broken, the parts do not really grow together, as do the parts of a broken bone, but they are merely cemented, or, as it were, soldered together by newly-added portions of the shell-substance.

As to the origin of the skeleton, it may be stated that it is not in any case a primary formation; that is, it does not at once appear as a bony structure in any animal; but, on the contrary, it is the result of successive changes which take place in pre-existing tissues.

The central basis of the skeleton appears, in the embryo of every vertebrate animal, as a cylindrical, fibrous sheath filled with simple cells containing a jelly-like substance; this constitutes what anatomists call the chorda-dorsalis or notochord, and it is from this notochord that the centrums, that is, the main bodies of the vertebræ, are developed.

And, in general terms, it may be stated that in the place of every bone in a vertebrate animal, there is at first only a clear soft substance. In the development and growth of the animal this substance becomes progressively more and more firm, acquiring, in turn, the nature of membrane or ligament, and then, perhaps, of cartilage; and then ossification or real bone-making next ensues.* The ossification, or the introduction of the earthy particles, that

---

* The chemical composition of the skeleton in four prominent kinds of vertebrate animals, is shown in the following table from Owen:

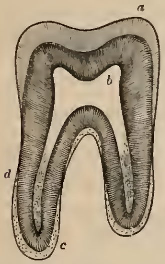
	MAN.	HAWK.	TORTOISE.	COD.
Phosphate of Lime with a trace of Fluate of Lime	59.63	64.39	52.66	57.29
Carbonate of Lime	7.33	7.03	12.53	4.90
Phosphate of Magnesia	1.32	0.94	0.82	2.40
Sulphate, Carbonate, and Chlorate of Soda	0.69	0.92	0.90	1.10
Gluten and Chondrin	29.70	25.73	31.75	32.31
Oil	1.33	0.99	1.34	2.00
	100.00	100.00	100.00	100.00

is, phosphate and carbonate of lime and other substances, does not take place uniformly throughout the whole extent of the pre-existing tissue, but only at certain points, called centers of ossification, and from these points the ossification or bone-making extends, so as, at length, to make complete the whole bone.

The mouth of the Vertebrates has two jaws; and, excepting in the Birds and Turtles, these, with comparatively few exceptions, are armed with teeth, which may be noticed here, although teeth are not regarded as really a part of the true skeleton (see p. 55).

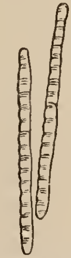
The teeth of vertebrate animals are bone-like in their general appearance. But, although they are in part composed of bony material called cement, they are mainly composed of substances called dentine and enamel, the dentine being the chief constituent.

Fig. 32.



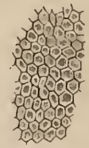
Longitudinal Section of a Molar tooth of Man. Enlarged.
a, enamel; *b*, pulp-cavity; *c*, cement; *d*, ivory or dentine.

Fig. 33.



Enamel Fibers of Human tooth. Mag. 350 diameters.

Fig. 34.



Surface of the enamel, with the ends of the enamel fibers. Calf. Mag. 350 diameters.

Dentine or ivory differs from bone mainly in containing less animal matter, in being denser, and in having no lacunæ or canaliculi. Dentine has exceedingly fine tubes for the passage of the plasma, that is, the colorless fluid of the blood, through its substance; but, unlike bone, it does not have tubes of sufficient size to allow of the passage of the red particles of the blood.

Enamel is still denser and harder than dentine; it is the hardest of all the tissues of the animal structure, and contains less animal matter than any other tissue.

Excepting in a few kinds, such as the halibut, flounder (Fig. 338), and fishes closely related to these, the organs of the Vertebrates are arranged in pairs on the two sides of the body. The eyes are two in number, ears two, and the locomotive appendages never exceed four. And the locomotive organs are directed towards the heart, and not towards the nervous centers as in the Invertebrata.

All the Vertebrates—excepting only the fish known as the amphioxus—have red blood which is propelled throughout the system, in veins and arteries, by a muscular organ called the heart.

The blood of all the Vertebrate animals is composed of a colorless or yellowish liquid called plasma, and exceedingly minute particles called corpuscles or disks which float in the plasma. These corpuscles vary greatly in form and size in different animals (Figs. 35–41).

The corpuscles of the blood of the Vertebrates are of two kinds—*red corpuscles* and *colorless corpuscles*—the former being much more numerous than the latter.*

---

* "That the red corpuscles are in some way or other derived from the colorless corpuscles, may be regarded as certain; but the steps of the process have not been made out with perfect certainty. There is very great reason, however, for believing that the red corpuscle is simply the nucleus of the colorless corpuscle somewhat enlarged and flattened from side to side; changed, by development within its interior of a red coloring matter, and set free by the bursting of the sac or wall of the colorless corpuscle. In other words, the red corpuscle is a free nucleus."

"The origin of the colorless corpuscles themselves is not certainly determined, but it is highly probable that they are constituent cells of certain

In form, blood corpuscles are circular, oval, or elliptical, and, as already indicated, more or less flat and disk-like. In all the Mammalia they are circular, except in the Camel family in which they are elliptical. In Man their two broad surfaces are somewhat concave, as plainly seen in those which have their edges turned towards the observer (Fig. 35). In some kinds of animals their two broad surfaces are convex, as in the Ostrich, Triton, Stickleback, etc. (Figs. 37, 38, 40).

In some kinds of the Vertebrata, as in Man, the red corpuscles of the blood are so minute that it would take more than 10,000,000 of them to cover a square inch of surface;

---

parts of the solid substance of the body which have been detached and carried into the blood, and that this process is chiefly effected in what are called the *ductless glands*, from whence the detached cells pass, as *lymph corpuscles*, directly or indirectly into the blood."

"The following facts are of importance in their bearing on the relation between the different kinds of corpuscles:

"(*a*). The invertebrate animals which have true blood corpuscles, possess only such as resemble the colorless corpuscles of man."

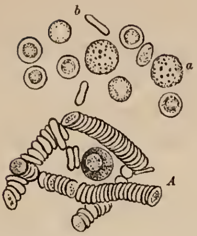
"(*b.*) The lowest vertebrate animal, the Lancelet (Amphioxus), possesses only colorless corpuscles; and the very young embryos of all vertebrate animals have only colorless and nucleated corpuscles."

"(*c.*) All the vertebrated animals the young of which are born from eggs, have two kinds of corpuscles—colorless corpuscles, like those of man, and large red-colored corpuscles, which are generally oval, and further differ from those of man in presenting a nucleus. In fact, they are simply the colorless corpuscles enlarged and colored."

"(*d.*) All animals which suckle their young, have, like man, two kinds of corpuscles—colorless ones, and small, colored corpuscles—the latter being always flattened and devoid of any nucleus. They are usually circular, but in the camel tribe they are elliptical. And it is worthy of remark, that in these animals the nuclei of the colorless corpuscles become elliptical."

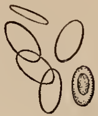
"(*e.*) The colorless corpuscles differ much less from one another in size and form, in the vertebrate series, than the colored. The latter are smallest in the little Musk Deer, in which animal they are about a quarter as large as those of man. On the other hand, the red corpuscles are largest in the Amphibia (or Frogs and Salamanders), in some of which animals they are ten times as long as in man."—HUXLEY, "Lessons in Elementary Physiology," p. 69.

FIG. 35.



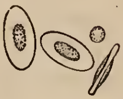
Blood corpuscles of Man. A, Blood in coagulation, the red corpuscles arranging themselves face to face, like a pile of plates or a roll of coins. *a*, colorless corpuscle; *b*, corpuscle with the edge turned towards the observer. Magnified 450 diameters.

FIG. 36.



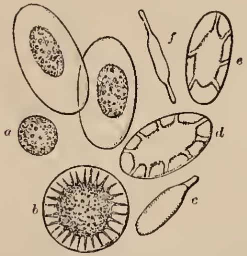
Blood corpuscles of a Pigeon. Magnified 450 diameters.

FIG. 37.



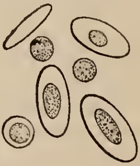
Blood corpuscles of an Ostrich. The smallest is a colorless corpuscle. Magnified 450 diameters.

FIG. 38.



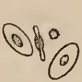
Blood corpuscles of a Triton. *a*, colorless corpuscle; *b*, *c*, *d*, *e*, and *f*, altered colored corpuscles. Magnified 450 diameters.

FIG. 39.



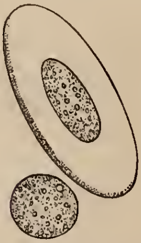
Blood corpuscles of a Frog. The smaller ones are colorless corpuscles. Magnified 450 diameters.

FIG. 40.



Blood corpuscles of a Stickleback. Magnified 450 diameters.

FIG. 41.



Blood corpuscles of the Siren; the smaller a colorless corpuscle. Magnified 450 diameters.

Figs. 30–36, showing the form and relative size of the blood corpuscles in the blood of various kinds of Vertebrate animals—the corpuscles represented in various attitudes.

and 120,000,000,000 of them, put together, would have no more than a cubic inch in bulk! And in the blood of the Musk Deer, the red corpuscles are only one-fourth as large as in Man.

In the blood of Man the colorless corpuscles are larger than the red corpuscles, and they are also more irregular in form than the latter; and what is especially noteworthy, is the fact that they constantly change their form by what may be called contraction and dilatation. Therefore it is not strange that, as they float in the plasma of the blood, and constantly exhibit themselves under new forms, they remind the observer of the Amœba and other similar low forms of animal life.

By diluting freshly-drawn blood with water, the colorless corpuscles are killed, and distended by the absorption of water, perhaps, and then their real structure is plainly seen. And they are found to be sacs having thin walls, and containing a clear granular fluid, and a central body or nucleus; in a word, they are simply nucleated cells, differing in no essential particular from the cells described on pages 12 and 13.

As regards size, the representatives of the Branch of Vertebrates, taken as a whole, are by far the largest of all the members of the Animal Kingdom. There are many kinds, however, that are very small.

Although it is highly probable, if not really certain, that the Vertebrates may be divided naturally into more classes than are usually recognized, the most generally adopted classification of this Branch of the Animal Kingdom recognizes but four or at most five classes.*

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* Agassiz, in his "Essay on Classification," recognizes eight classes in the Branch of the Vertebrates, thus:

1. Mammals. 2. Birds. 3. Reptiles. 4. Amphibians. 5. Selachians (Sharks, Skates, etc.). 6. Ganoids (Gar-pike, Sturgeon, etc.). 7. Fishes proper. 8. Myzontes (Lampreys, etc.).

It will be seen that this increase of classes results from dividing the old group of Fishes into four groups.

For our present purposes, we may divide the Vertebrates into five Classes, as follow:

I. MAMMALIA, or air-breathing, warm-blooded animals, which bring forth living young, and nourish them with milk; which usually have the skin covered with hair, fur, or wool; lungs suspended in a cavity separated by a diaphragm from the cavity of the abdomen, and unconnected with air-sacs; a heart with four cavities; a complete and double circulation of the blood; blood-corpuscles non-nucleated, and in nearly all cases circular; the skull with two occipital condyles; the lower jaw composed of only two pieces, and articulated directly with the skull without the intervention of a quadrate bone; and teeth generally present, enameled, and certain kinds implanted by two or more roots; as Man, Beasts of prey, our domestic quadrupeds, etc.

II. AVES, or Birds, or air-breathing, warm-blooded animals, which lay eggs from which by brooding they hatch their young; which have their skin covered with feathers; lungs connected with air-sacs, and not separated from the cavity of the abdomen by a diaphragm; a heart with four cavities; a complete and double circulation of the blood; blood-corpuscles, oval and nucleated; the skull with only one occipital condyle; each half of the lower jaw composed of several pieces and articulated to the skull by means of a quadrate bone; and which in all cases are destitute of true teeth.

III. REPTILIA, or air-breathing, cool-blooded animals, which lay eggs from which their young are hatched without incubation; which have the body covered with plates or scales; the lungs not connected with air-sacs, and not separated from the abdominal cavity by a diaphragm; a heart with three or four cavities; the blood-corpuscles oval and nucleated; the skull with one occipital condyle; each branch of the lower jaw composed of several pieces, and articulated to the skull by means of a quadrate bone; and teeth with only one root, or set in a groove, or wanting; as Turtles, Saurians, and Snakes.

IV. BATRACHIA, or Amphibians, or cool-blooded animals, which breathe by gills in the young state, but which afterwards have lungs (in some kinds both lungs and gills), and thus become air-breathers; which lay their egg in the water, or in damp places; which are destitute of plates or scales (in existing species); which have three cavities in the heart; nucleated blood-corpuscles; and the skull with two occipital condyles; as Frogs and Toads, Salamandars, etc.

V. PISCES, or Fishes, or gill-breathing, cool-blooded animals, which live in the water, and which in general lay eggs from which their young are hatched; and which have only two cavities in the heart.

These classes stand in the order of their rank, the first named being the highest, and the last named the lowest.

Many writers regard Reptiles and Batrachians as one class, and call them all Reptiles, thus making only four classes of the Vertebrates.* They then subdivide this class into Reptiles proper and Amphibians.

In all these classes the fundamental idea of the Vertebrates is more or less plainly manifested, and the principal parts of the skeleton in the different classes correspond to one another, part to part, spinal column to spinal column, and locomotive members to locomotive members; the

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Dr. Theodore Gill, in a recent paper (see American Jour. of Sci. and Arts, 3d Series, No. 36, Vol. VI.), recognizes eight classes in the Vertebrata. He writes his classification thus:

Branch VERTEBRATA.
  A. Sub-branch CRANIOTA.
    Super-class MALLEIFERA.
      I. Class Mammalia.
    Super-class QUADRATIFERA.
      (Sauropsida.)
      II. Class Aves.
      III. Class Reptilia.
      (Batrachopsida.)
      IV. Class Batrachia.
    Super-class LYRIFERA.
      V. Class Pisces,
      VI. Class Elasmobranchia.
    Super-class MONORRHINA.
      VII. Class Marsipobranchia.
  B. Sub-branch ACRANIA.
      VIII. Class Leptocardii.

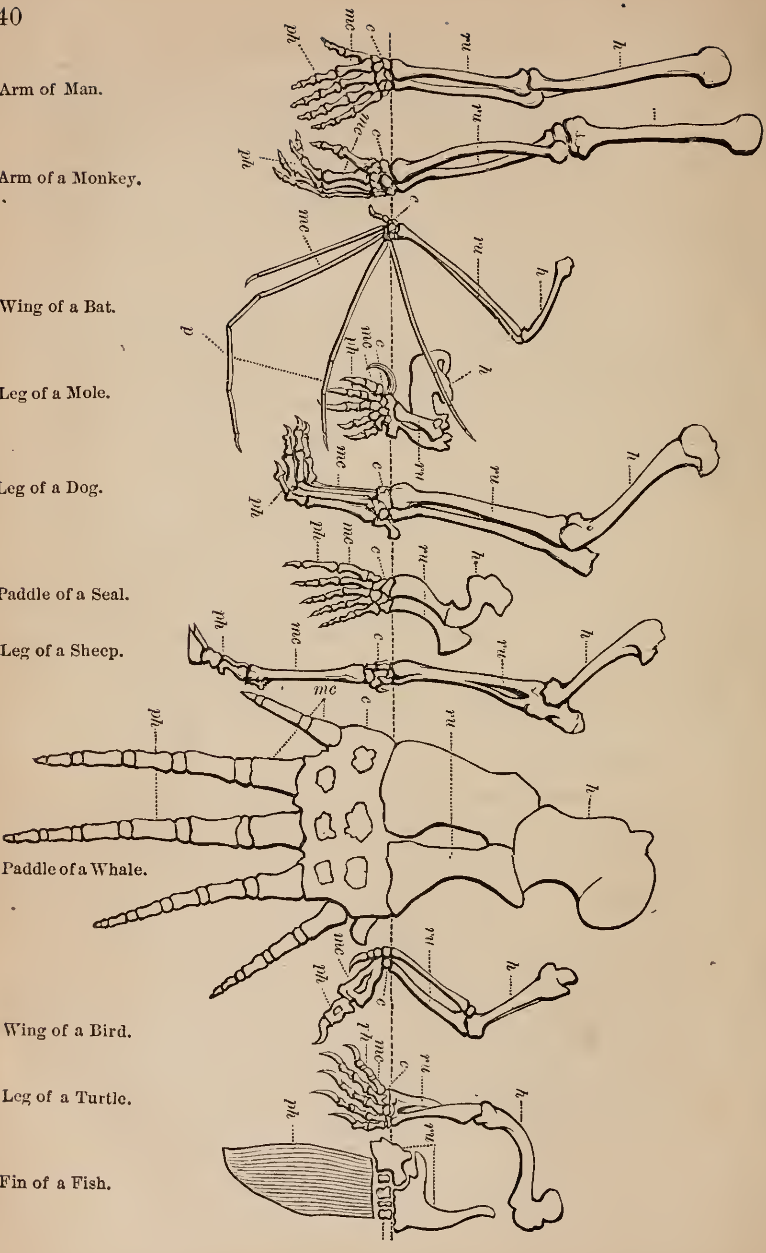

FIG. 42. Arm of Man.

FIG. 43. Arm of a Monkey.

FIG. 44. Wing of a Bat.

FIG. 45. Leg of a Mole.

FIG. 46. Leg of a Dog.

FIG. 47. Paddle of a Seal.

FIG. 48. Leg of a Sheep.

FIG. 49. Paddle of a Whale.

FIG. 50. Wing of a Bird.

FIG. 51. Leg of a Turtle.

FIG. 52. Fin of a Fish.

members in each case, however, being modified according to the function to be performed, whether it be that of standing, or grasping, or walking, or running, or leaping, or springing, or flying, or creeping, or swimming; but the general plan is always the same. Figs. 24 and 26, where corresponding parts are marked by the same letter or letters, show how the skeleton of Man and the skeleton of a Bird, correspond to one another; and Figs. 42–52, which exhibit the form of the bones of the forward locomotive members of several kinds of Vertebrates, show clearly that the arm of Man, the arm of the Monkey, the wing of the Bat, the leg of the Mole, the leg of the Dog, the paddle of the Seal, the leg of the Sheep, the paddle of the Whale, the wing of the Bird, the leg of the Turtle, and the fin of the Fish, are but different expressions of one and the same fundamental idea. In the figure of each one of these members, *h* stands for humerus; *ru*, for radius and ulna; *c*, for carpus; *mc*, for metacarpus; and *ph*, for phalanges or bones of the fingers.

PRINCIPAL TOPICS CONSIDERED IN CHAPTER II., SECTION I.

The Vertebrates defined.——Skeleton.——Vertebræ.——Cerebro-spinal system.——Spinal cavity or neural canal.——Hæmal cavity.——All vertebrates constructed on one plan.——Bones; their structure, and composition.——Difference between bones and shells.——Origin of the vertebrate skeleton.——Chorda-dorsalis.——Jaws of the Vertebrates.——Teeth—cement, dentine, and enamel.——Arrangement of the organs of the Vertebrates.——The blood of Vertebrates.——Forms and sizes of the blood corpuscles.——Structure of the colorless corpuscles.

Relative size of the Vertebrates.——Classification of the Vertebrates as regards *Classes.*——Parts of the skeleton in the different classes of the Vertebrates compared.

SECTION II.

THE CLASS OF MAMMALIA OR MAMMALS.

SUB-SECTION I.

THE MAMMALIA CONSIDERED AS A CLASS.

ALL vertebrate animals which bring forth living young and nourish them with milk, belong to the Class of Mammalia. The members of this class are more or less covered with hair in some one of its forms, as ordinary hair, fur, or wool; although some kinds of mammals, as the Cetaceans or Whales, have this covering only before they are born!

The various forms of the hair of the Mammalia are mere horny modifications of the epidermis or outside skin.

Man, Monkeys, Beasts of Prey, all of our herds and flocks and their wild allies, are familiar examples of this class.

The form and size of the Mammals vary exceedingly. They are of all sizes, from the little shrews hardly two inches in length, up to the whales, some of which attain an enormous bulk and the length of a hundred feet! All except the Cetaceans have two pairs of limbs, and have the terminal phalanges protected by a nail, claw, or hoof; and the forward pair of limbs is present in all.

Of all animals, the Mammals most fully and perfectly exhibit the true animal structure and functions.

Their digestive system is extensive and complicated.

Their circulatory system consists of a heart with four cavities, arteries which carry the blood to all parts of the body, veins which conduct the blood back to the heart, and capillary vessels which connect the termination of the arteries with the beginning of the veins.* Their blood is warm, and the red corpuscles are non-nucleated (Fig. 35).

Their respiratory system consists of lungs suspended in a cavity called the chest, and which is separated from the cavity of the abdomen by a muscular partition called the diaphragm.

The motatory system of the Mammals consists of muscles, tendons, and ligaments, together with the solid skeleton to which these are attached.

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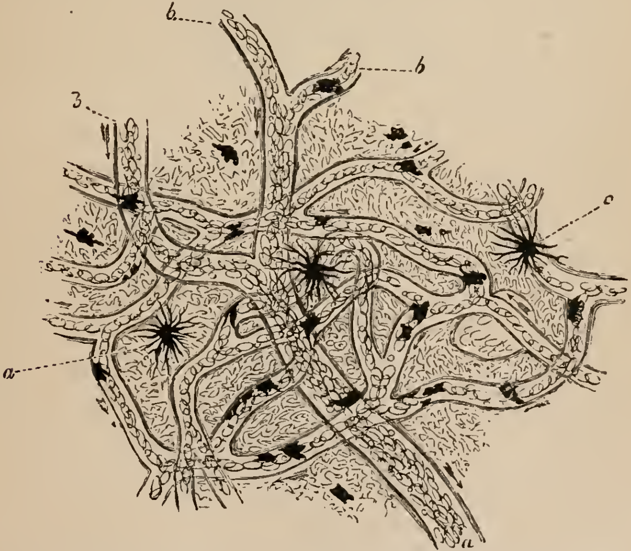
* Some idea of capillary circulation in general, may be obtained from the accompanying highly magnified particle of the web of a Frog's foot.

Fig. 53.



Minute portion of the web of a Frog's foot. Showing capillary circulation--the blood disks plainly seen in the capillaries. Highly magnified.

a, trunk of a vein; *b*, *b*, *b*, capillaries; *c*, *c*, pigment cells.

Their nervous system, consisting of the brain—composed of two hemispheres—the spinal cord and nerves, and nerve-masses, is more fully developed than in any other animals.

Their reproductive system is the most perfect that is found in the whole Animal Kingdom.

They are all endowed with vocal organs; and they excel all other animals in intelligence.

As the Mammals are the highest class of the Vertebrates, and consequently the highest class in the whole Animal Kingdom, we should become specially familiar with their structure, not only for the sake of the information which we may thereby gain, but that we may better understand the structure of the Vertebrates in general, and that we may have a standard with which to compare the lower Vertebrates.

The general structure of the digestive system in Mammals is shown in Fig. 54.

The function of the digestive system, as has already been stated, is to convert the food into blood.

The acts by which the food is converted into blood, may now be briefly stated.

The food is seized by the animal and placed in the mouth, where it is masticated by the teeth, and where it is mixed with a fluid called saliva, which comes from cavities and glands situated in or near the cavity of the mouth.

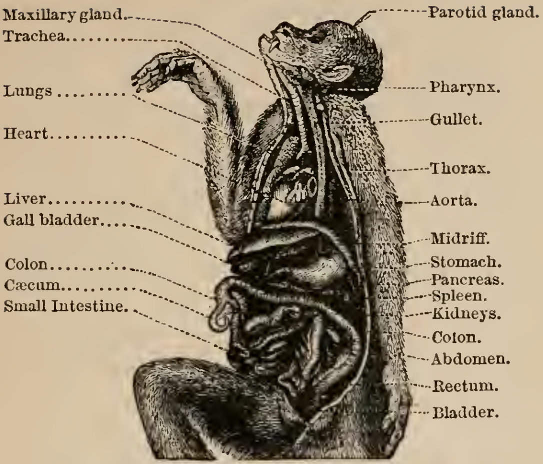
After mastication it is pressed backwards by the tongue, and it then passes into the pharynx, where swallowing commences, and whence the food passes through the gullet into the stomach.

By the action of a fluid called the gastric juice, the food, while in the stomach, is changed into a substance called chyme.

From the stomach the chyme passes into the small intestines, where it mingles with a fluid secreted by its walls, and with the bile and pancreatic juice—liquids furnished by the liver and pancreas—and, during the passage through the small intestines, digestion is completed, the chyme being changed into a substance called chyle.

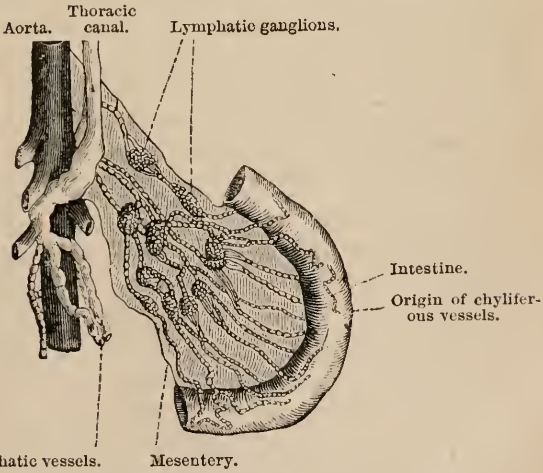
The chyle is now absorbed by numerous vessels called the lacteals.

FIG. 54.


Maxillary gland.
Trachea.
Lungs
Heart.
Liver.
Gall bladder.
Colon.
Cæcum.
Small Intestine.
Parotid gland.
Pharynx.
Gullet.
Thorax.
Aorta.
Midriff.
Stomach.
Pancreas.
Spleen.
Kidneys.
Colon.
Abdomen.
Rectum.
Bladder.

Digestive Apparatus of a Mammal—a Monkey.

FIG. 55.


Aorta.
Thoracic canal.
Lymphatic ganglions.
Intestine.
Origin of chyliferous vessels.
Lymphatic vessels.
Mesentery.

Chyliferous Vessels.

which originate in the mucous membrane of the intestines, and which, after passing through and being more or less modified by the mesenteric glands, open into an organ called the thoracic duct.

This duct, which begins in the abdomen, carries the chyle, which is constantly becoming more and more like blood, and pours it into the left sub-clavian vein, which is one of the great branches that lead directly to the heart.

The absorption of chyle by a certain kind of vessels has just been alluded to; and we may properly notice here the vessels which constitute the true Absorbent system. While absorption of a certain kind—as described on page 10—is carried on by various tissues, the walls of the stomach, walls of the intestines, and blood-vessels, there are in all the Vertebrates, except the Amphioxus (Fig. 352), special organs of absorption, which we will now briefly describe.

Besides the capillaries, already referred to, and the veins which they open into on the one hand, and the arteries which they open into on the other, there are, in all parts of the body which have ordinary capillaries—excepting only the brain and spinal cord, eyeball, cartilages, tendons, and, possibly, the bones—other vessels or capillaries called absorbents or lymphatics. The Lymphatic or Absorbent system consists of vessels which originate in the tissues, in excessively minute roots or tubes, and which open only into trunks which bear fluid away from them—there are no vessels to bring anything to the absorbents. They are filled with a liquid known as lymph, and which is slightly yellowish or transparent; or milky, as in that part of the system known as the lacteals or chyliferous vessels. They often anastomose or unite with one another along their course; and at intervals they enter certain bodies called lymphatic glands, from which they emerge as new trunks and continue onward as before.

Ultimately most of the lymphatics empty their contents into the thoracic duct, which leads into the left subclavian vein. This is especially true of the lacteals or chyliferous vessels, which are filled with the fibrin, the fatty and other matters, the products of digestion, derived from the small intestine (Fig. 55).

It must be added, however, that other lymphatics empty their contents by a common canal into the right subclavian and right jugular veins.

The blood of a living animal is in constant circulation, nourishing and building up every part of the body. The fact of the circulation of the blood was first demonstrated in 1619 by William Harvey, an English physician.

In the Mammals—and the same is true of Birds—the organs of the circulatory system, as already stated, are a heart to propel the blood, tubes, or arteries, to carry the blood from the heart to all parts of the body, and other tubes, or veins, to bring the blood back to the heart, and minute capillary vessels to connect the terminations of the arteries with the beginning of the veins.

The arteries are deeply situated, and are composed of three tissues—the inner continuous with the inner membrane of the heart; the middle fibrous and elastic, with the fibers arranged circularly; and the outer cellular and also elastic. When empty the arteries do not readily collapse; when cut they do not readily heal.

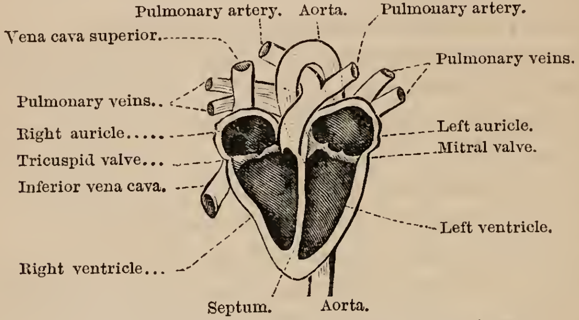
The veins have thinner walls than the arteries, but are also composed of three tissues, the middle tissue of which is made up of irregularly arranged fibers. When empty the veins readily collapse, when cut they readily heal. The veins follow nearly the same course as the arteries, but, in most cases, they are nearer the surface, and they are more numerous than the latter.

The blood flows in the arteries in a continued stream, and with considerable force. This is owing to the action of the heart, and also to the elasticity of the arteries themselves.

The blood passes from the arteries into the veins by means of the capillaries, as before indicated, and the impulse it receives from the heart determines its course in the veins. The veins, in most cases, are provided with valves, permitting the flow of blood towards the heart, but preventing its re-flow in the opposite direction.

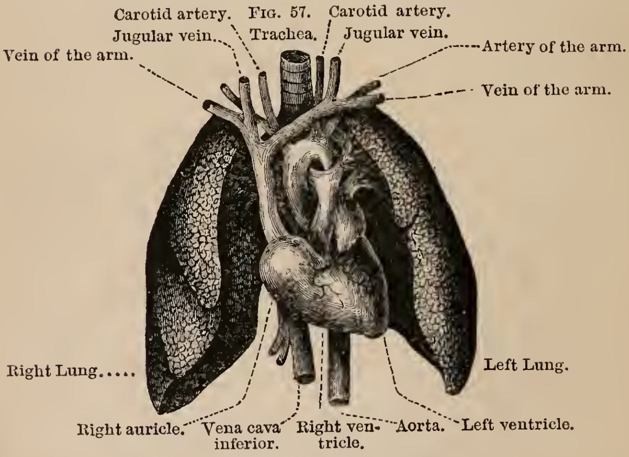
The heart in the Mammals and in the Birds contains four cavities—a right auricle and right ventricle, and a left auricle and a left ventricle, the two cavities in the right half being completely separated from the two cavities in

FIG. 56.


Pulmonary artery.
Aorta.
Pulmonary artery.
Vena cava superior.
Pulmonary veins.
Pulmonary veins..
Right auricle.....
Left auricle.
Tricuspid valve...
Mitral valve.
Inferior vena cava.
Left ventricle.
Right ventricle...
Septum.
Aorta.

Theoretical Section of Heart of the highest Mammal—Man.

FIG. 57.


Carotid artery.
Carotid artery.
Jugular vein.
Trachea.
Jugular vein.
Vein of the arm.
Artery of the arm.
Vein of the arm.
Right Lung.....
Left Lung.
Right auricle.
Vena cava inferior.
Right ventricle.
Aorta.
Left ventricle.

Lungs, Heart, etc., of the highest Mammal—Man.

the left half, by a vertical partition. Each auricle, however, communicates by little openings, regulated by valves, with the ventricle below it.

The heart is a very powerful muscle, and its cavities dilate and contract with remarkable regularity while life lasts.

As the auricles dilate they receive the blood; the right, that which is brought to it from the body by the veins, and the left, that which flows into it from the lungs; when full the auricles contract, forcing their contents into the ventricles; these dilate as they fill, and then suddenly contract upon their contents, the right forcing the blood into the pulmonary artery, and the left into the aorta, the great artery which gives rise to all the arteries of the body, excepting only the pulmonary arteries.

The whole course of the blood in Mammals, and in Birds, may now be briefly stated. By the contraction of the right auricle, the blood which it contains is forced into the right ventricle, little valves preventing its return; by the contraction of the right ventricle, the blood is forced thence into the pulmonary artery, through which it enters the lungs, where it is purified and changed from a bluish to a bright red color; from the lungs the pulmonary veins conduct it to the left auricle; the left auricle forces it into the left ventricle, by whose contraction it is forced through the aorta and its various branches to all parts of the body. Through the veins, as before stated, it comes back to the right auricle of the heart—having lost the amount required for nourishing and building up the system, and having been increased by the amount added by the chyle, in the manner already described on page 44.

It must be added here, however, as a matter of fact, that in point of time the ventricles are the first, and the auricles the second to contract in each systole.

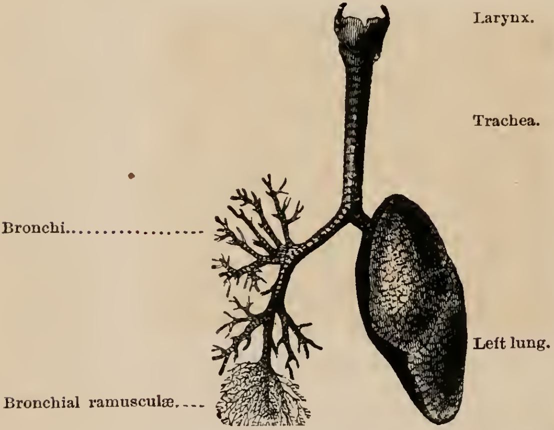
The circulation above described is what is called a complete and double circulation. It is called complete because all of the blood circulates through the lungs before going through the body; and it is called double because the blood passes through two sets of capillary vessels—one set belonging to the lungs, and the other set to the body.

The circulation of the blood through the lungs is called the pulmonary circulation, and that through the body, the systemic circulation.

The respiratory apparatus of Mammals consists mainly of lungs, and an air-tube or trachea, to carry the air to and from these organs.

At no stage of their existence are their "visceral arches" furnished with branchial or gill-like appendages.*

FIG. 58.



Lungs and Trachea of the highest Mammal—Man.

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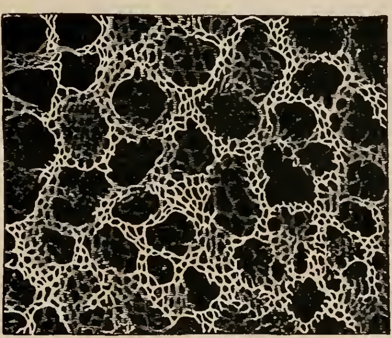
* In the embryonic condition of all the Vertebrata, the part of the body-wall which lies at the sides, and just behind the mouth, exhibits a series of vertical parallel thickenings; these thickenings are called the "visceral arches." The spaces between these arches become thinner and thinner, and at length clefts or "branchial fissures" take the place of the thin spaces, and thus there are openings from the exterior surface of the animal into the anterior portion of the digestive cavity. In the higher adult vertebrates the "branchial fissures" are obliterated, or so modified as apparently to disappear; but in Fishes and certain Batrachians they remain in connection with the gill-bearing arches.

The lungs are two in number, situated in the chest, and each is enveloped with a membrane called the pleura. The cavity of the chest is also lined with the same sort of membrane. The upper or anterior end of the air-tube opens into the pharynx. The lower or posterior part divides into two branches called the bronchial tubes, one of which passes to each lung and there divides and subdivides into a great number of branches, as seen in Fig. 58.

The lungs are made up of a vast number of small cavities or cells, into each one of which a branch of the bronchial tube opens; and it is in these cells that the air acts upon the blood contained in the capillary vessels, above mentioned, and renders it pure.

FIG. 59.



Small portion of Human lung. Magnified.

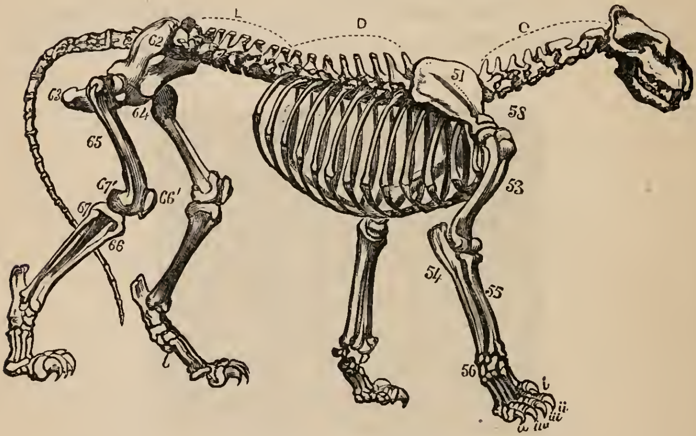
The act of breathing is performed by the involuntary movements of the walls of the chest, including that of the diaphragm, that is, the broad muscle which separates the cavity of the chest from that of the abdomen.

During ordinary circumstances there enters into the lungs of a man about five and a half quarts of air per minute.

We may now consider the motatory apparatus, or the skeleton, the muscles, the ligaments, and the tendons. The general structure of the skeleton of Mammals may be seen in Figs. 24 and 60. This general structure is modified in each order, according to the functions which the animals are to perform.

In the adult mammals the skeleton is very hard and solid, but in the very young it is cartilaginous. The ossification, or bone-making, begins, as already stated on page 32, at various points in the cartilage, but these gradually coalesce as the animal grows older.

FIG. 60.



Skeleton of the Lion (*Felis leo*).

C, cervical vertebræ; D, dorsal vertebræ; L, lumbar vertebræ; 51, scapula; 53, humerus; 54, ulna; 55, radius; 56, carpus; 58, position of the clavicles reduced to clavicular bones suspended in the flesh; 62, 63, 64, pelvis; 65, femur; 66, tibia; 67, fibula; 66′, patella; 67′, fabella ; i, ii, iii, etc., digits.

To prove that cartilage is the basis of all the bones which make up the skeleton, it is only necessary to place any bone in weak muriatic acid, which dissolves out the mineral substances and leaves the cartilage of the same form and size as the bone itself.

The surface of each bone is covered with a membrane called the periosteum, as already stated.

The surfaces of bones present elevations or processes, and depressions, some of which are for the attachment of muscles.

Some of the bones, as those of the face, are fixed firmly together by mere closeness of position; others are united, as in the head, by sutures; others are implanted, as the teeth, if we regard teeth as bones (see page 56); and others, as the main bones of the trunk and limbs, are held together by ligaments.

The Skeleton is divided into three well-defined regions, as the head or skull, trunk, and extremities.

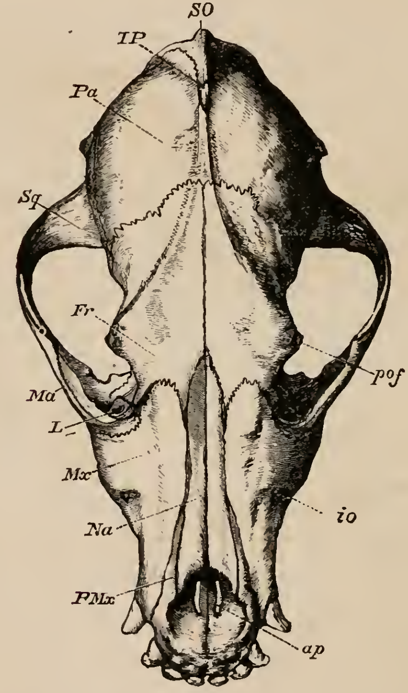
The skull consists mainly of the cranium or brain-case, together with parts protecting and supporting the organs of hearing, sight, and smell, the whole formed of numerous bones, closely united by sutures, or by anchylosis (Figs. 61, 62, 63). To the cranium, on the lower surface, are attached the lower jaw—or *mandible* as it is called by anatomists—and the hyoidean apparatus (*sh*, *eh*, *ch*, *bh*, *th*, Fig. 62).

The form and structure of the skull of one of the most common of the Mammals, namely, the Dog, are shown in the three following wood-engravings (Figs. 61, 62, 63), from Flower's "Osteology of the Mammalia," an excellent hand-book for the pupil who would gain more information of the Mammalian skeleton than our space here allows us to give. The names, however, of the different parts of the skull, are annexed to the engravings, as they stand in Flower's work just named.

The skull in all the Mammalia has two occipital condyles (*oc*, Fig. 63) or articulating surfaces, by which it is articulated to the first vertebra—or atlas—of the neck, instead of one articulating surface or condyle, as in Birds and Reptiles.

In all the Mammals, the upper jaw is fixed to the cranium, and is therefore immovable; the lower jaw is formed of two pieces only, one on each side—the two in some species fixed firmly together by what is called anchylosis—and is articulated directly with the skull, without the intervention of a bone which anatomists call the quadrate bone, such as exists in Birds and Reptiles; and the teeth are enamelled. And it may be added here that

FIG. 61.



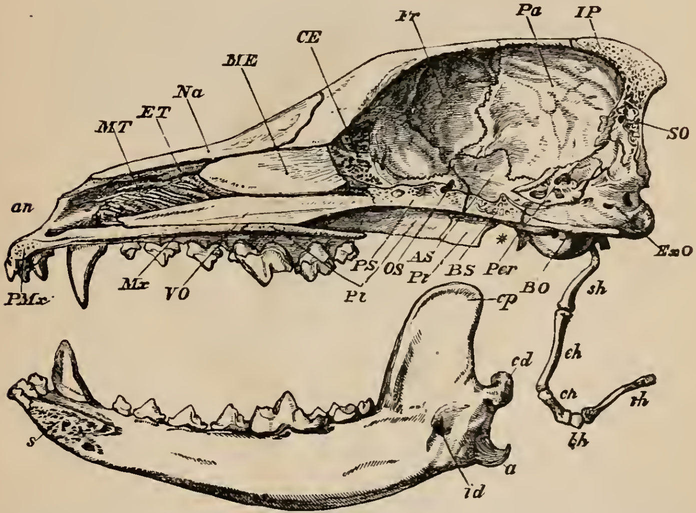
Cranium of a Dog, upper surface. Reduced in Size.

SO, supraoccipital; IP, interparietal; P*a*, parietal; S*q*, squamosal; F*r*, frontal; M*a*, malar; L, lachrymal; M*x*, maxilla; N*a*, nasal; PM*x*, premaxilla; *ap*, anterior palatine foramen; *io*, infraorbital foramen; *pof*, postorbital process of frontal bone.

the Mammals are the only animals that have teeth implanted by two or more roots or fangs.

The teeth are not regarded as a part of the true skeleton, being developments from the mucous membrane, which is fundamentally the same as the external integument of the body, and continuous with it. The teeth of the Mammals are confined to the lower jaw and to the premaxillary and maxillary bones above (Figs. 61, 62, 63). Some kinds of

Fig. 62.

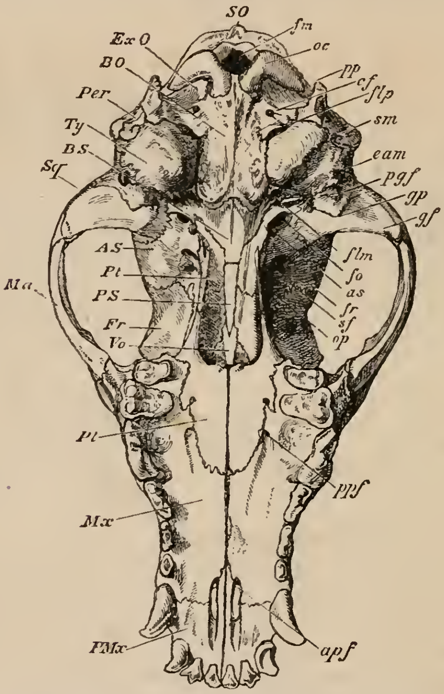


Skull of a Dog; longitudinal and vertical section, with the right half of the mandible or lower jaw and hyoid arch—the lower jaw displaced downwards to show its whole form. Reduced in size.

an, anterior narial aperture; MT, maxillo-turbinal bone; ET, ethmo-turbinal; N*a*, nasal; ME, ossified portion of the mesethmoid; CE, cribriform plate of the ethmo-turbinal; F*r*, frontal; P*a*, parietal; IP, interparietal; SO, supraoccipital; E*x*O, exoccipital; BO, basioccipital; P*er*, periotic; BS, basisphenoid; P*t*, pterygoid; AS, alisphenoid; OS, orbitosphenoid; PS, presphenoid; P*l*, palatine; V*o*, vomer; M*x*, maxilla; PM*x*, premaxilla; (*sh*, stylohyal; *eh*, epihyal; *ch*, ceratohyal; *bh*, basihyal ; *th*, thyrohyal;)=the right half of the hyoidean apparatus; *s*, symphysis of the mandible; *cp*, coronoid process; *cd*, condyle; *a*, angle; *id*, inferior dental canal; *, the part of the cranium to which the condyle is articulated.

mammals, as the Sloths, Armadillos, Anteaters, etc., are difficient in teeth; and the Duckbills have horny plates instead of teeth. In some kinds of mammals, as in Man, a

FIG. 63.

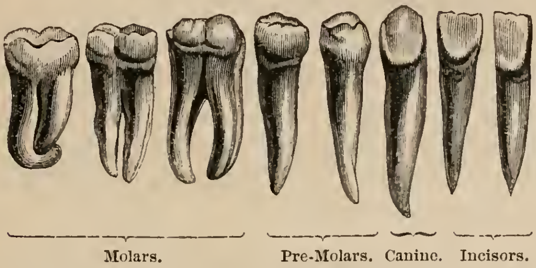


Cranium of a Dog, under surface. Reduced in size.

SO, supraoccipital; E*x*O, exoccipital; BO, basioccipital; P*er*, mastoid portion of the periotic; T*y*, tympanic bulla; BS, basisphenoid; S*q*, zygomatic process of the squamosal; M*a*, malar; AS, alisphenoid; P*t*, pterygoid; PS, presphenoid; F*r*, frontal; V*o* vomer; P*l*, palatine; M*x*, maxilla; PM*x*, premaxilla; *fm*, foramen magnum; *oc*, occipital condyle; *pp*, paroccipital process; *cf*, condylar foramen; *flp*, foramen lacerum posterius; *sm*, stylo-mastoid foramen; *eam*, external auditory meatus; *pgf*, postglenoid foramen; *gp*, postglenoid process; *gf*, glenoid fossa; *flm*, foramen lacerum medium; *fo*, foramen ovale; *as*, posterior opening of alisphenoid canal; *fr*, foramen rotundum and anterior opening of alisphenoid canal; *sf*, sphenoidal fissure or foramen acelrum anterius; *op*, optic foramen; *ppf*, posterior palatine foramen; *apf*, anterior palatine foramen.

certain number of teeth, called the milk teeth, are shed and replaced by others. But there are many kinds of mammals in which no such shedding and replacement have been observed.

FIG. 64.



Teeth of the left half of the lower jaw of the highest Mammal—Man.

And here it may be stated that it is common among zoölogists to indicate the kinds and number of teeth in any mammal, by a formula. Thus the formula for the teeth of Man is :

$$i\ \frac{2-2}{2-2},\quad c\ \frac{1-1}{1-1},\quad pm\ \frac{2-2}{2-2},\quad m\ \frac{3-3}{3-3}=32.$$

which means that Man has two *incisor* teeth in each side of each jaw, one *canine* tooth in each side of each jaw, two *pre-molar* teeth in each side of each jaw, and three *molar* teeth in each side of each jaw, making in all thirty-two teeth.

Sometimes the dash (—) is omitted—as it obviously merely indicates that the teeth of a given kind are equally arranged in the right and left side of the mouth—and then the formula is written thus :

$$i\ \frac{4}{4},\quad c\ \frac{2}{2},\quad pm\ \frac{4}{4},\quad m\ \frac{6}{6}=32.$$

With these examples all similar formulæ will be readily understood.

In general the Mammalia have seven vertebræ in the neck ; but there are some important exceptions. The Manati (see p. 114) have only six, one species of Sloth has only six, and the Three-toed Sloths have nine !

The first and second cervical vertebræ are articulated with each other and with the two occipital condyles (Fig. 63, *oc*), by synovial joints, that is, by joints that are smooth, and constantly supplied with a lubricating fluid called synovia; all the other vertebræ have between their centrums certain disks composed of elastic fibrous material, which serve to give elasticity to the spinal column, and enable it the better to withstand shocks, without injury.

The dorsal vertebræ are in many cases thirteen; but the number varies from ten to twenty-four. The lumbar vertebræ (Fig. 24, *lv*, and Fig. 60, L)—the vertebræ between the hind ribs and the sacrum—are six or seven, in many cases; but the number varies from two to nine; and the caudal from four to forty-six.

In adult mammals the centrums of the vertebræ are anchylosed with the neural arch. During growth the centrums are furnished with epiphyses, that is, portions of bone separated by cartilage from the main body of the bone.

All of the Mammalia except the Cetaceans, have certain vertebræ which are called sacral; these form the sacrum (Fig. 24, *s*), or posterior part of the pelvis; and they vary in number in different mammals from one to nine.

The muscles in Mammals, and in all the Vertebrates, cover the skeleton, and constitute what is well known as the flesh. They are attached to the bones by tough fibers called tendons. These are of a white color, and without feeling.

The muscles, as already stated on page 18, are composed of bundles of fibers, and these again of bundles of fibers more and more delicate; and the elementary fiber is so fine that it can be seen only by means of the microscope.

The muscles are the only parts of the body which possess the property of contractility. Each bundle of muscular fibers receives nervous filaments or threads, and it is under the influence communicated by these that the muscles contract, or relax. By cutting off the nerve which communicates with a muscle, in a living animal, the muscle is paralyzed.

Some muscles, as those of the limbs, obey the will of the animal; others, as those of respiration, may obey the will, but they also act independently of it; and there are others, as the heart and stomach, over which the will has no control.

Those muscles which are wholly independent of the will receive their influence from the ganglionic system, described on page 60.

As regards the reproductive system of the Mammalia, it is the most perfect in the Animal Kingdom, as already remarked. And, although in some respects* the Mammalia agree with Birds and Reptiles in their development from the embryo, it may be stated here, that the relation of parent and offspring in this class is more intimate than in any other class of animals.

The Nervous system of the Mammals is more highly developed than that of any other animals. It is composed of two parts—the nervous system of animal life or cerebro-spinal system, and the ganglionic or nervous system of organic life.

The *Cerebro-spinal system* is composed of the cerebrum, cerebellum, and spinal cord, and their branches, as seen in Fig. 25. The nerves of this system extend to the muscles, organs of the special senses, etc. A vertical section of the

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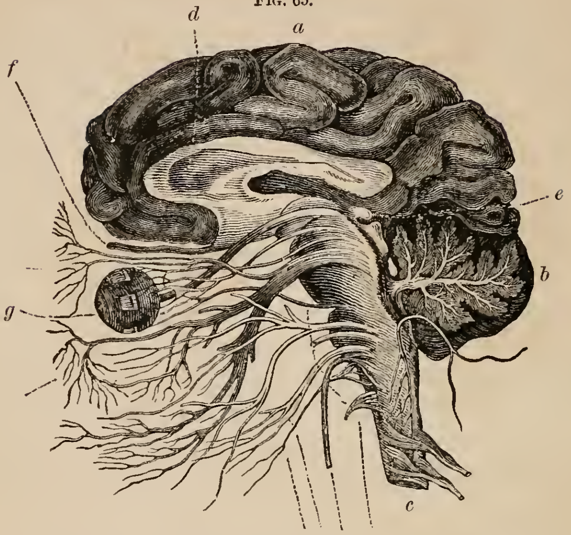
* The Mammalia, Aves (Birds), and Reptilia, agree in having, in their development from the embryo, an amnion (innermost fœtal envelope), and an allantois (a second fœtal envelope), and hence are often called the ALLANTOIDEA; and as they are not provided with gills at any period of their existence they are also called ABRANCHIATE VERTEBRATA.

While Batrachia and Pisces have neither amnion nor allantois (or only a rudimentary one), are often called the ANALLANTOIDEA; and as they have either permanent gills, or gills at some stage of their existence they are often called the BRANCHIATE VERTEBRATA.

FIG. 65.



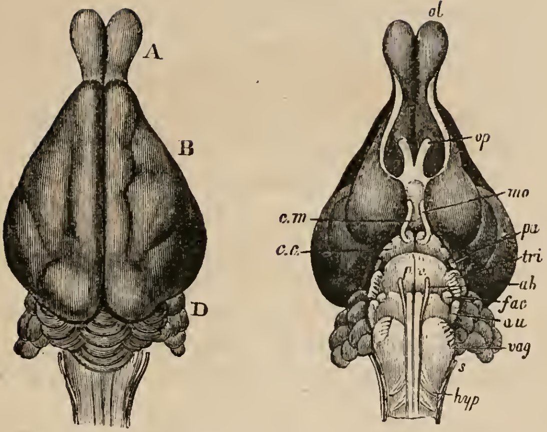
Section of the Brain, etc., or principal portion of the cerebro-spinal system of the highest Mammal—Man.

a, cerebrum ; *b*, cerebellum ; *c*, spinal cord; *d*, section of the corpus callosum; *e*, optic lobes; *f*, olfactory nerves; *g*, eyeball and optic nerve.

principal portion of the cerebro-spinal system of the highest mammal—Man—is seen in Fig. 65, and the anterior portion of the cerebro-spinal system of a Rabbit is seen in Fig. 66.

The *Ganglionic system* is composed of a number of small ganglions or masses of nervous matter, united to each other by filaments, and by the same means to the cerebro-spinal system. These ganglions are arranged in the cavity which contains the heart, lungs, and the other internal organs, and in a double row on each side of the spinal column ; and many others are scattered through the

Fig. 66.



Brain or principal portion of the cerebro-spinal system of a Rabbit. Upper surface on the right, lower on the left.

A, olfactive lobes; B, cerebral hemispheres; D, cerebellum; *ol*, olfactive lobes; *op*, optic nerve; *mo*, motor oculi; *cm*, corpora mamillaria; *cc*, crus cerebri; *pv*, pons varolii; *pa*, patheticus; *tri*, trifacial; *ab*, abducens; *fac*, facial; *au*, auditory; *vag*, vagus; *s*, spinal accessory; *hyp*, hypoglossal.

viscera. The nerves of this system extend to the vital organs, as the stomach, heart, lungs, liver, intestines, etc.

The nerves originating in the cerebro-spinal system of the highest mammal, namely, Man, amount to forty-three pairs—twelve pairs arising within the cranium, and leaving that cavity by apertures in the cranial bones, and thirty-one pairs arising from the spinal cord, and leaving by apertures situated between the vertebratæ. Each of these pairs is composed of a great number of extremely fine threads or fibers inclosed in a sheath. At their origin, the fibers which make up the nerve are called roots, and, in the case of the spinal nerves, are grouped into anterior and posterior roots. On the posterior root there is a ganglion through which the filaments pass and after that unite with the anterior root.

The brain itself is insensible, not feeling even when irritated or cut; but it is nevertheless the seat of sensation, and the source of voluntary motion. The nerves bring to the brain the impressions which they receive, and they carry the influences which the brain sends to all parts of the body. And it is an interesting fact that there are nerves which carry only sensation to the brain, and others which transmit the will of the brain to the different parts of the body—that is, there are nerves of sensation, and nerves of motion. And experiment has shown that the posterior roots, above described, are nerves of sensation, and the anterior are nerves of motion.

The Mammals are richly endowed with all the special senses—as sight, hearing, smell, taste, and touch; and they have special organs appropriate to the exercise of those senses.

In the Mammals, and in all other vertebrates, the eyes are two in number, and situated in cavities of the skull, called orbits. The globe of the eye is a hollow sphere formed by three membranes, one within another, and filled with humors more or less fluid. The outside membrane is thick and tough, and is called the *sclerotic*. In front, and continuous with it is the translucent *cornea*, through which the rays of light pass into the interior of the eye. The membrane next to the sclerotic is the *choroid*, which in front is separated from the sclerotic, and which is there called the *iris*, and is the part which gives the color to the eye. The iris readily contracts and dilates, and thus the aperture at its center, called the *pupil*, is diminished or enlarged according to the amount of light to which the eye is exposed. The next, and inside membrane is the *retina*, which is an expansion of the optic nerve. It is upon this that the images of objects are received and make impressions which are carried to the brain by the optic nerve.

The humors which occupy the cavity of the eye are of different densities. The fluid which fills the spaces in the front part of the eye is called the *aqueous humor;* it is clear and watery. Behind the pupil there is a somewhat firm and transparent body called the *crystalline lens.* Behind this lens, the whole of the remainder of the globe is filled with the *vitreous humor*, a perfectly transparent gelatinous liquid.

The eyes of Mammals are protected by two lids furnished with eyelashes, and the muscles of the eyes are so arranged that these organs can be rolled so as to look in different directions without moving the head.

The ears of the Mammals are very complicated. These are always two in number, and situated in the hinder part of the head. In Man, and in most other mammals the ear is divided into three portions—the external ear, the middle ear, and the internal ear.

The *external ear* consists of the conch and the auditory tube; it is in the latter that the ear-wax is formed.

The *middle ear* is an irregular cavity, separated from the auditory tube by a partition called the tympanal membrane or *drum;* this cavity has several openings, one of which is through the Eustachian tube, which opens into the back part of the mouth. In the middle ear there is a chain of four small bones called the *malleus,* the *incus,* the *stapes,* and the *os orbiculare.*

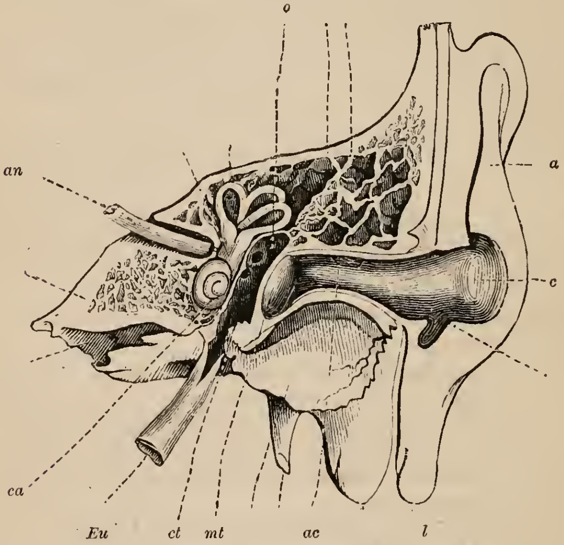
The *internal ear* is situated within the temporal bone, and is composed of three parts—the vestibule, the semi-circular canals, and the cochlea.

The *vestibule* is in the middle, and communicates with the tympanum by an opening called the fenestra ovalis. The *semi-circular canals* are three in number, and are rounded, bony, and membranous tubes. The *cochlea* is half bony and half membranous, and resembles a snail shell in shape, and it is divided into two parts by a longitudinal partition; and it communicates with the vestibule and with the tympanum by an opening called the fenestra rotunda.

The internal ear contains a watery liquid, and in this liquid are suspended membranous pouches also filled with a liquid, and in these are the terminating filaments of the acoustic nerve or nerve of hearing.

We may now understand how hearing is secured. The vibrations of the air are collected by the external ear, and conducted by the auditory tube to the drum or tympanal membrane; the vibrations of the drum are communicated to the chain of little bones, and by these to the internal ear, where they act upon the nervous filaments, which receive the impression and convey it to the brain through the auditory nerve.

Fig. 67.



Auditory apparatus of the highest Mammal—Man.

a, external ear; *l*, lobe of the ear; *c*, concha; *ac*, auricular canal; *mt*, membrana tympani or drum; *ct*, cavity of the tympanum; *o*, opening in wall of the tympanum; (the fenestra ovalis and rotunda are near this opening); *Eu*, Eustachian tube; *v*, vestibule; *sc*, semi-circular canals; *ca*, cochlea; *an*, acoustic nerve.

The nose is the organ of smell. In the Mammals it constitutes a part of the face. The nostrils are two in number. In the Mammals the outer walls of the nose are made of cartilage, but internally the nostrils communicate with bony cavities, and these cavities are lined with what is called the pituitary membrane, on which are expanded the olfactory nerves or nerves of smell.

Odors are particles of extreme fineness which escape from different bodies and spread through the air like vapors. These are received through the nose and excite the nerves of smell, and the nerves of smell send the impressions which they receive to the brain.

The taste is the sense by which animals perceive the flavor of bodies, and by which they are mainly guided in the choice of their food; though smell also aids them in this matter. The nerves of the taste terminate in the tongue, and in little bodies called papillæ which cover its surface. In some kinds of Mammals these are very harsh, as in the cat tribe, and in the ox; in others, as in Man and in the dog, they are very soft and delicate.

The sense of touch in the Mammals is spread over the whole body, since the nerves of sensation expand over the whole surface of the body; but the sense of touch in its greatest perfection is limited to certain parts of the body. In Man the sense of touch in its true power resides in the hand—in the fingers, which are especially adapted for the exercise of this faculty. No other mammal, probably, exhibits this sense in so great perfection as he; though the trunk of the Elephant possesses the same in a remarkable degree.

With the exception of the Birds and a few reptiles, the Mammals are the only animals that are furnished with vocal organs. So that if the Mammals, Birds, and Reptiles were removed from the earth, no vocal sounds would be heard; for we must bear in mind here, that the buzzing of bees, the hum of flies, the stridulating noise of the grasshoppers, and the shrill of the crickets, are not vocal sounds, but are noises which these animals make mainly with their wings.

The *larynx* is the organ of voice in Man and in all other mammals. It is situated at the upper part of the trachea or wind-pipe, being suspended from the bone of the tongue. It is formed of several cartilaginous pieces, called respectively the thyroid cartilage, the cricoid cartilage, and the arytænoid cartilage. The most prominent part of the thyroid in Man, is called *Adam's apple.* A mucous membrane continuous with that of the mouth, nostrils, and pharynx, lines the larynx, and, extending into the wind-pipe, becomes the mucous membrane of the lungs themselves. In the interior of the larynx this mucous membrane forms four folds—two upper ones, called the *false vocal cords,* and two lower ones, called the *true vocal cords,* the space between the latter being called the *glottis.* The vocal cords are under the control of the will, and can be relaxed or tightened. The cavity between the true and false vocal cords is called the *ventricle of the larynx.* As the passage of food or drink into the larynx is attended with danger, producing suffocation unless speedily removed, the upper aperture is protected by an organ of triângular shape called the *epiglottis.*

In ordinary breathing, the air passes the vocal cords without producing any sound; but when they are drawn tighter, by the exercise of the will of the animal, they narrow the aperture of the glottis, and the air in passing them causes them to vibrate, and the vibrations produce the voice. The voice is modified according to the condition of these cords, being higher when their tension is great, and lower when their tension is less.

Only one mammal—Man—has the power of making the sounds of the voice into words; he alone has the power of true speech.

As for Instinct, the Mammals are not more remarkable than many other animals, as for example, Birds and Insects; but in Intelligence, as before stated, they are the highest in rank of all the animals of the globe.

The Class of Mammalia has been variously divided and sub-divided by different naturalists. A natural division of this class into two Sub-classes may be made if we take as a basis of classification the manner and condition in which the young are brought forth, and the structure which determines the manner and condition in which the young are brought forth. The Sub-classes on this basis, are :

I. VIVIPAROUS, or PLACENTAL MAMMALIA, or those whose young have the form of their parents at the time of birth. These are the true or Typical Mammalia ; that is, they best represent the Class. Man, Monkeys, Lions, Horses, Cows, Sheep, Goats, etc., are examples of this Sub-class.

II. SEMI-VIVIPAROUS, or NON-PLACENTAL MAMMALIA, or OÖTICOIDS, or those whose young are born in a very immature, that is, in an embryonic condition. as the Kangaroo, Opossum, etc.

De Blainville, Huxley, and others, recognize three subclasses of the Mammalia instead of two. The third subclass is obtained by dividing the Semi-viviparous Mammals into two groups. These three Sub-classes are based on the nature of the reproductive system : .

I. MONODELPHIA, the same as the Placental Mammalia, or those whose young at birth have the form of their parents, as Man, Monkeys, Lions, Horses, Cows, etc.

II. DIDELPHIA, the same, nearly, as the Non-placental Mammalia, or those whose young are born when of very small size, and in a very immature condition, as the Kangaroos, Opossums, etc.

III. ORNITHODELPHIA, or Bird-like Mammalia, or those whose structure in some respects is like that of Birds, as the Duck-bill and Echidna. This group was formerly included in that of the Semi-viviparous or Non-placental Mammals.

Recognizing three Sub-classes as given above, these groups and the Orders into which they may be divided, may now be presented in one view, thus :

I. MONODELPHIA.

1. Bimana, or erect two-handed mammals; the hands never used for locomotion; Man only.
2. Quadrumana, or non-erect four-handed mammals; the hands used, generally, for locomotion; as Monkeys.
3. Carnivora, or flesh-eating mammals, with sharp teeth and sharp claws. as the Cats, Dogs, etc.
4. Ungulata, or mammals whose four feet are hoofed; as the Horse, Cow, Sheep, etc.
5. Toxodontia, or fossil pachydermatous mammals, with peculiar teeth, the outer incisors being bow-shaped.
6. Hyracoidea, or very small hoofed mammals, in some respects allied to the Rodents, and to the Rhinoceros; as the Damans.
7. Proboscidea, or mammals whose nose is prolonged into a trunk or proboscis; as the Elephant, etc.
8. Sirenia, or mammals somewhat whale-like in form, and herbivorous in habits; as the Manatus, Dugong, etc.
9. Cetacea, or mammals somewhat fish-like in form, with paddle-like limbs, and carnivorous habits; as Whales, Porpoises, etc.
10. Chiroptera, or hand-winged mammals—mammals adapted for flight; as Bats.
11. Insectivora, or mammals with teeth, etc., adapted for eating insects; as Shrews, Moles, etc.
12. Rodentia, or mammals with teeth fitted for gnawing; as Squirrels, Beavers, Rats, etc.
13. Edentata, or mammals deficient in teeth; as the Armadillo, Sloth, Anteater, etc.

II. DIDELPHIA.

14. Marsupialia, or mammals with a sack or pouch in which the young are carried after birth.

III. ORNITHODELPHIA.

15. Monotremata, or mammals which have some affinities with birds; as the Duckbill and Echidna.

For further remarks on the classification of the Mammalia, the student is referred to the writings of Gill, Dana, Huxley, and others.*

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* One of the most recent classifications of the Mammalia is that of Dr. Gill. His classification, omitting all except the sub-classes and orders, stands thus:

MONODELPHIA.

1. Primates.
2. Feræ.
3. Ungulata.
4. Toxodontia (fossil).
5. Hyracoidea.
6. Proboscidea
7. Sirenia.
8. Cete.
9. Chiroptera.
10. Insectivora.
11. Glires.
12. Bruta.

DIDELPHIA.

13. Marsupialia.

ORNITHODELPHIA.

14. Monotremata.

The classification of the Mammalia, according to Professor J. D. Dana, stands essentially thus:

I. Archonts.

1. Bimana, or Man.

II. Megasthenes (from the Gr. *megas*, great, and *sthenos*, strength).

2. Quadrumana or Four-handed mammals, as Monkeys.
3. Carnivora or Flesh-eaters, as Lions, Dogs, Weasels, etc.
4. Herbivora or Plant-eaters, as Elephants, Horses, Sheep, etc.
5. Mutilata, or Mammals having paddle-like limbs, as Whales, etc.

III. Microsthenes (from the Gr. *mikros*, small, and *sthenos*, strength).

6. Chiroptera or Hand-winged Mammals, as Bats.
7. Insectivora, or Insect-eaters, as Moles, Shrews, etc.
8. Rodentia or Gnawers, as Squirrels, Beavers, Rats, etc.
9. Edentata, or Mammals deficient in teeth, as Armadillos, Sloths, Ant-eaters, etc.

IV. Oöticoids (from the Gr. *oön*, an egg).

10. Marsupialia or Pouched Mammals, as the Kangaroos, Opossums, etc.
11. Monotremata or Bird-like Mammals, as the Duckbill, etc.

SUB-SECTION II.

THE ORDER OF BIMANA OR MAN.

THE structure of Man is essentially the same in kind as that of other mammals, differing only, or mainly, in degree; but the degrees of difference separate him widely from all other mammals, and place him in an order by himself, and far above all other members of the animal kingdom.

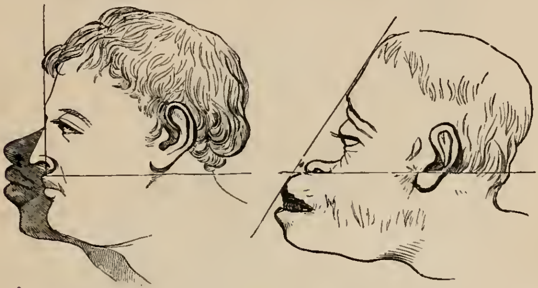
Man is the only animal to which the erect position is natural; his whole organization is perfectly adapted to that attitude. His foot is broad and plantigrade; that is, the sole of the foot is placed flat upon the ground; the leg bears vertically upon the foot; the toes are short, and all on the same level, and the innermost toe is much the longest and cannot be opposed to the others; the pelvis is short and broad; the back-bone is in slight alternate curves; and the head is beautifully poised at the very summit of the structure.

Man alone has one pair of limbs liberated wholly from the function of mere locomotion, and made subservient for higher purposes.

The hand of man is superior in its structure and in its functions to the corresponding member of any other animal. His hand has sometimes been called an intellectual member; for all that his mind can conceive, whether in literature, invention, or art, his hand can express in visible forms. The name Bimana comes from the Latin *bis*, twice, and *manus*, a hand.

The brain of man is relatively the largest among all the Mammalia, and absolutely larger than that of any other animal excepting that of the elephant and the whale. And of all animals man exhibits the largest facial angle.*

FIG. 68. FIG. 69.



Illustrating the Facial angle of a Negro, a Caucasian, and an Orang-outang.

His face is a model of beauty, and is endowed with a greater power of expression than is to be found in any other animal. Man alone has the power of true speech. Even physically considered, he is the highest possible expression of a vertebrate.

But Man is the highest representative of the Animal Kingdom, not only on account of his superior form and higher physical organization, but, above all, on account of those high mental and spiritual endowments which belong to him alone, and which enable him to understand and appreciate the wonderful and sublime harmonies of the material and moral world, and his own relations to the Author of Nature and of Revelation.

---

* If a straight line be drawn from near the opening of the external ear to the base of the nose, and if this line be intersected by another straight line drawn from the most prominent part of the forehead to the most prominent part of the upper jaw, the angle thus formed is called the *Facial angle.* In the Dog the facial angle is about 20°; in the highest Monkeys or Apes, about 40°; in Negroes, 65° to 70°: in the White race, 75° to 90 or 95°.

SUB-SECTION III.

THE ORDER OF QUADRUMANA OR MONKEYS.

As their name indicates, the animals belonging to this order have each of their four extremities hand-like; that is, the first digit on each extremity is a thumb, opposable to the fingers. The name Quadrumana comes from the Latin *quatuor*, four, and *manus*, a hand.

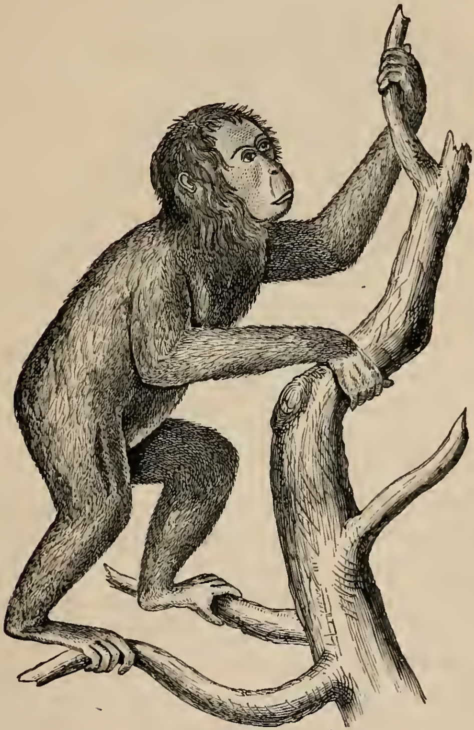
The animals of this order are popularly known as apes, monkeys, and baboons. Some of them bear a general resemblance to the members of the human family; but there are wide differences between the Quadrumana and Man, even when physically considered.

The erect attitude, as we have seen, is the natural one for Man; not so with any of the Quadrumana. Although some kinds may stand and even walk somewhat erect, this attitude is unnatural and insecure, the hind feet, or hind "hands," then resting on their outer edges only, and their narrow pelvis being unfavorable for the maintenance of an equilibrium.

It is true that the hands of the Quadrumana bear a very close resemblance to human hands; but, although admirably adapted to grasping and climbing, they are greatly inferior to the perfect hand of Man, in delicacy of structure and functions. In many species the face presents something human-like in appearance; but the elongated muzzle, even of the highest species, is far more like that of the ordinary quadrupeds than like that of man.

The Quadrumana are selfish, crafty, malicious, and thievish. Some species are docile, and can be trained to perform remarkable feats; but none have ever been trained to render really useful service for man. They inhabit the warm regions of both hemispheres.

FIG. 70.

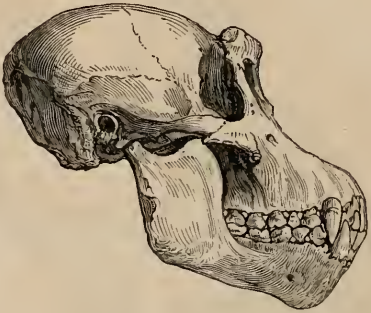


Orang-Outang, *Simia satyrus*, Linnæus.

All the Quadrumana of the Eastern hemisphere, except the Lemuroidea (page 78), are called CATARRHINE monkeys, from the position of their nostrils, which are oblique and placed near together. This term comes from two

Greek words, *kata*, down, and *rhin*, nose. The Catarrhine monkeys are the largest and the most powerful, and the most ferocious of all the Quadrumana, and those which bear the nearest resemblance to Man.* Their teeth are thirty-two, the same number as in Man. Some species of these monkeys, as the Gorilla, and Chimpanzee, of tropical Western Africa, the Orang-Outang, of Borneo, and the Gibbons, of India, are known as Man Apes or Anthropoid Apes. These have no tail, and to the casual observer they have something human-like in their appearance. The Chimpanzee and Orang approximate man in size, and the Gorilla is vastly more bulky than a man.

FIG. 71.



Skull of Chimpanzee, *Troglodytes niger*, Geoffroy. Much reduced in size.

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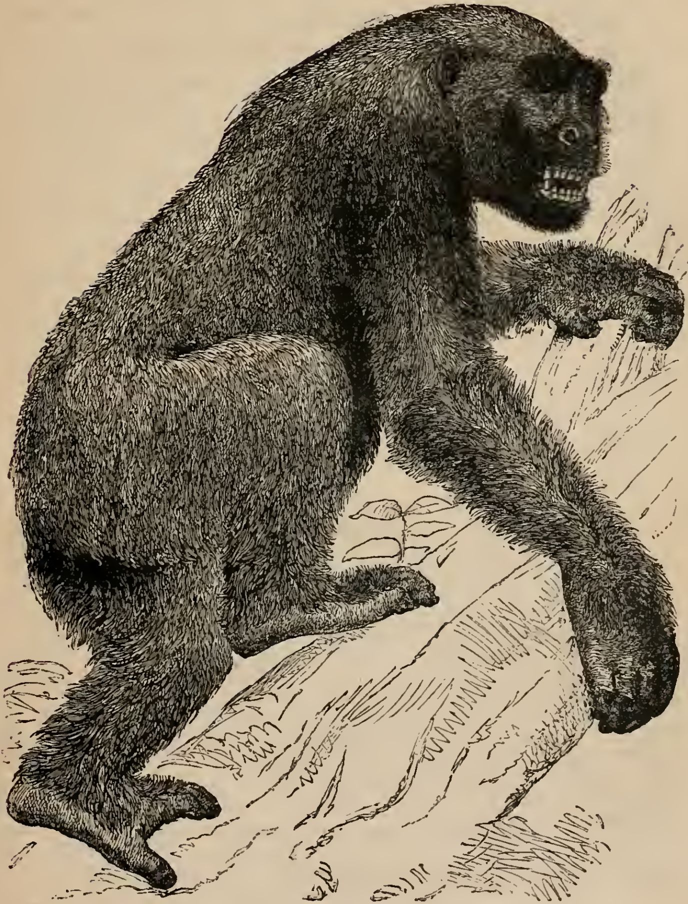
* Huxley, who includes both Man and the Quadrumana in one order, the Order of Primates, divides that order into three Sub-orders, thus:

Primates. {
Anthropidæ (Man).
Simiadæ (Apes and Monkeys).
Lemuridæ (Lemurs).

Dr. Theodore Gill (see Arrangement of Families of Mammals, Smithsonian Miscellaneous Collections), divides the Primates into two Sub-orders:

1. Anthropoidea (Man and Monkeys).
2. Prosimiæ (Lemurs, Tarsiers, Aye-Aye, etc.).

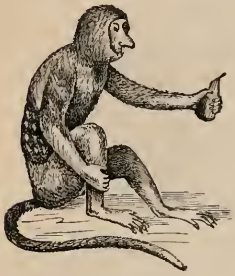
Fig. 72.



Gorilla, *Troglodytes Gorilla*, Savage.

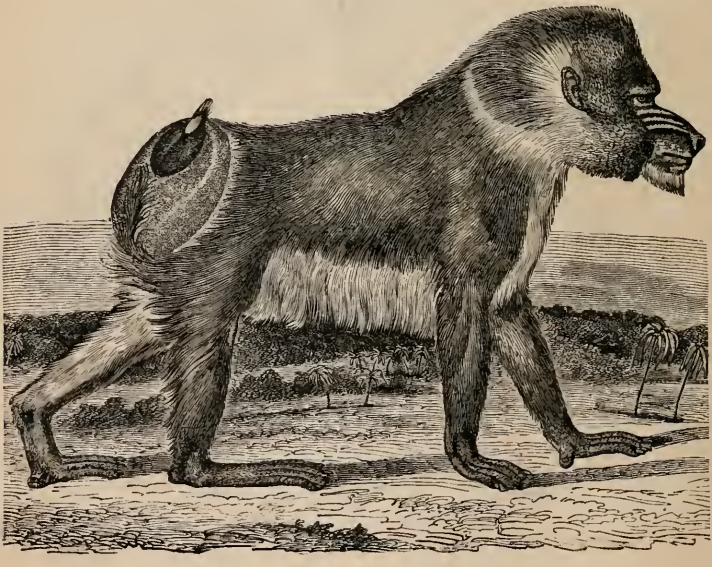
Of the tailed monkeys of the Eastern hemisphere, some of the more interesting are the Semnopitheci or Solemn Apes, of Asia and the Asiatic Archipelago, one of which, the Kahau (Fig. 73), is celebrated for its very long nose; the Guenons, which move in large troops and commit great havoc in fields and gardens; the Macacos, which have shorter limbs and longer muzzle than the Guenons; and the Barbary Ape that inhabits the precipitous sides of the Rock of Gibraltar. The Catarrhines also include all the quadrumana known as Baboons, and

FIG. 73.



Kahau, *Semnopithecus nasica*, Schreiber.

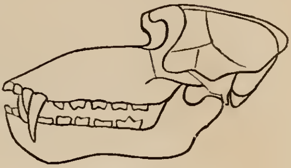
FIG. 74.



Mandrill or Baboon, *Cynocephalus*.

which are the ugliest and most ferocious of all the monkey tribes. They have the muzzle much lengthened and are often called Dog-headed monkeys, and Mandrills. They belong mainly to Africa and the Philippine Islands.

FIG. 75.

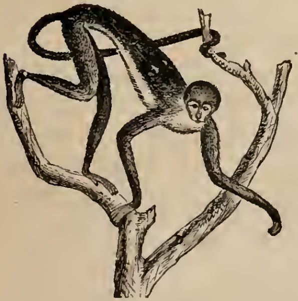


Skull of Baboon.
Cynocephalus.

All of the Quadrumana which inhabit America are called the PLATYRHINE monkeys, so named from the Greek *platus*, broad, and *rhin*, nose; they have the nose with the median septum broad—the nostrils wide apart. These monkeys, as a group, are smaller and less ferocious than the Catarrhines, and as a whole are regarded as inferior to them. Excepting the little monkeys called Marmosets (Fig. 77), which have only thirty-two, the Platyrhines have thirty-six teeth. And in many species the tail is prehensile—a characteristic not found in any catarrhine monkey.

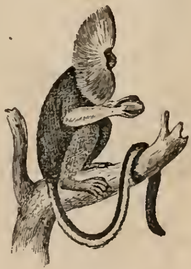
The prehensile tail of these monkeys is capable of being twisted firmly around branches of trees, and some species are thus able to sustain the entire weight of the body.

FIG. 76.



Spider Monkey, *Ateles belzebuth*, Brisson.

FIG. 77.



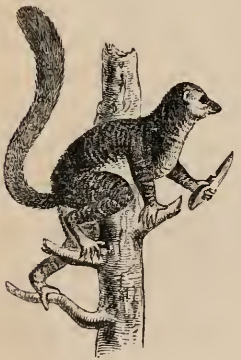
Marmoset, *Hapale chrysomelas*, Prince Maximilian.

The tail is also sensitive, and thus becomes both an organ of feeling and prehension, enabling the possessor to obtain small objects even where the hand cannot be inserted.

Prominent among the Platyrhine monkeys are the Howlers, large monkeys, which have a vocal apparatus by which they produce the most frightful howls; others are known as Weepers from their plaintive cry; others as Spider monkeys (Fig. 76), from their long and sprawling legs. All these, and many others, have the tail prehensile. Besides these there are the Fox-tailed, Squirrel, and Night monkeys, and the Marmosets mentioned above, all of which have non-prehensile tails.

The STREPSORHINE quadrumana are so named on account of their curved nostrils. The name is derived from two Greek words *streptos*, twisted, and *rhin*, nose. They inhabit Madagascar, Central and Western Africa, and India; and, excepting their four extremities, they much resemble the ordinary quadrupeds. They are best known as the Lemuroidea; and they are also often called Makis.

FIG. 78.

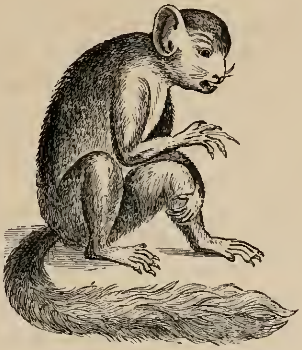


Lemur, *Lemur catta*, Linn.

True Lemurs have six incisors in the lower jaw and only four in the upper. Those known as Indri have only four incisors in the lower jaw. Those called Lorises live in the East Indies, and have a very slender body. The Galagos of Africa and the Tarsiers of the Moluccas have the tail tufted, and the eyes and ears large.

More curious than all the other lemuroids is the Aye-Aye, which, according to the latest authorities, must be placed here; but its true place has been regarded as somewhat doubtful. The Aye-Aye furnishes us with an example of a synthetic or *comprehensive* type; that is, a type which combines within itself characteristics which belong to two or more distinct groups. This strange animal inhabits Madagascar, and has a body about the size of that of a cat, and its tail is long and bushy, and curves downward. In the form, structure, and mode of growth of its incisor teeth, the Aye-Aye is like the Rodents; but in the form of its head and body, and in the opposable thumb of its hind feet, it is allied to the Quadrumana. The body is covered with short and soft grayish hair, and longer hairs of a very dark brown color. Its hand is unlike that of any other animal, being especially remarkable on account of the slenderness of the middle finger. So far as is known, the Aye-Aye is nocturnal in its habits. It readily climbs trees, and sometimes suspends itself by its hind feet head downward, in which position it is said to comb its tail with its long fingers! Its food is believed to be mainly grubs which it gets from beneath the bark of trees. The Aye-Aye is the type of a distinct family—Cheiromyidæ.

Fig. 79.



Aye-Aye, *Chiromys madagascarensis*, Cuvier.

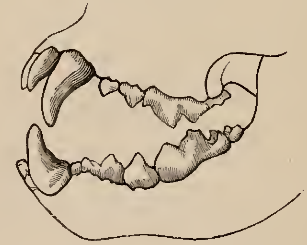
SUB-SECTION IV.

THE ORDER OF CARNIVORA OR FLESH-EATERS.

THE mammalia which compose this Order feed wholly or mainly upon flesh; and, with few exceptions, they capture the animals upon which they feed. They are distinguished from all other animals not only by their general appearance, but especially by their sharp teeth, sharp claws, and by their internal digestive apparatus.

The Carnivora have teeth of three kinds, and all of their teeth are covered with enamel. They have normally six incisors in each jaw, the lateral ones being the largest; a stout canine in each side of both jaws, just behind the incisors; and a variable number of molars which are wholly trenchant, or in part with tuberculous crowns. Thus the molars of the Carnivora are not properly grinding teeth, but those in the upper and lower jaws shut by each other so as to cut the flesh of the prey like a pair of shears.

FIG. 80



Teeth of a carnivorous animal.

The stomach of the Carnivora is simple, and the intestines relatively very short, thus perfectly adapted to their easily digestible food, which, as we have just stated, is the flesh of other animals.

The legs of the Carnivora have the proximal joints, that is, the joints nearest the body—as the upper ones of the humerus and femur—more or less covered by the general integument of the body; and the clavicles are imperfect or wholly wanting in this order.

The forms of the Carnivora are various, and each distinct typical form may be taken as the type of a distinct family. A few of the leading representatives may now be briefly noticed.*

Of all the Carnivora, the Cats or Felidæ are the most dexterous and rapid in their movements, and are endowed with the keenest senses, and are the most rapacious and formidable. In a word, they are typical Carnivora; that is, they are types or best representatives of the whole order. Their head is short and broad, the teeth and claws excessively sharp, and the latter are concealed in a sheath while the animal is walking or at rest, but are instantly thrust forth when occasion requires their use. The tongue is covered with sharp prickles pointing backwards; the number of mature teeth is twenty-eight or thirty, and the dental formula is, incisors $\frac{3-3}{3-3}$, canines $\frac{1-1}{1-1}$, premolars and molars $\frac{4-4}{3-3}$ or $\frac{3-3}{3-3}$. The feet are digitigrade, with five toes before and four behind. The soles are densely hairy, with naked pads on the ball of the foot and under each toe. The cushion-like nature of the bottom of their feet enables these animals to noiselessly approach their prey, which they seize by a sudden spring.

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* The Carnivora are often spoken of as comprising three great groups, the classification being based on their means and modes of progression, thus:—

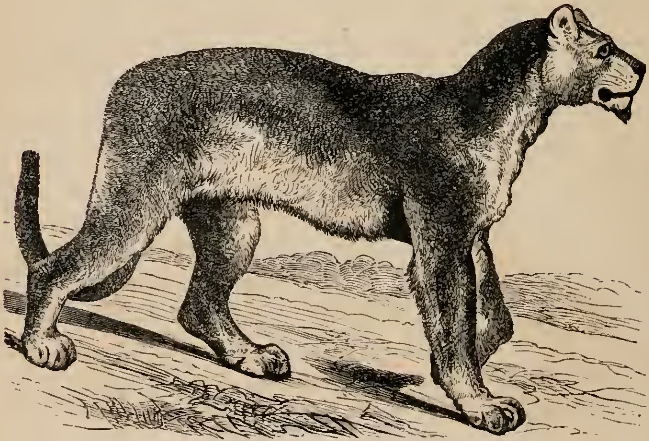
1. Digitigrades, from the Latin *digitus*, a finger, and *gradi*, to walk; or those which walk on the toes without touching the heel to the ground, as the Cats, Hyenas, Dogs, Weasels, etc.

2. Plantigrades, from the Latin *planta*, the sole of the foot, and *gradi*, to walk; or those which in walking place the sole of the foot flat upon the ground, as Raccoons, Bears, etc.

3. Pinnigrades, from the Latin *pinna*, a fin, and *gradi*, to walk; or those which progress by means of fin-like paddles, as the Seals and the Walrus. They are often called Pinnipedia.

The true Cats have a long and tapering tail, which in the Lion is tufted, and the molars are $\frac{4-4}{3-3}$. Such are the Lion of Africa and Asia, an animal whose body is eight feet long and whose body is of a tawny-yellow; the Royal Tiger of India, even longer than the Lion, and of a lively fawn color, beautifully striped with black; the Jaguar of South America, somewhat smaller than the Tiger, and of a brownish-yellow color beautifully marked with rosette-like figures on the sides; the Panther of Africa and India, of a fawn color with six or seven rows of black spots or

FIG. 81.

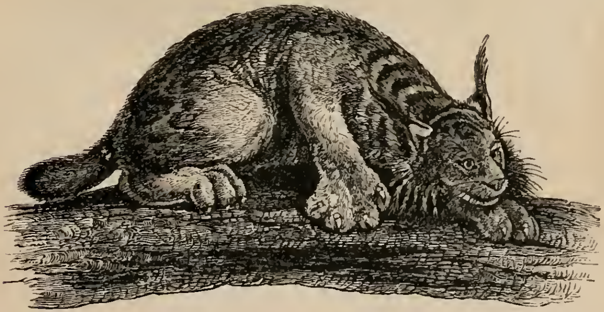


Puma, *Felis concolor*, Linnæus.

blotches on each flank; the Leopard of Africa and India, similar in appearance to the Panther, but with ten rows of smaller spots on the sides; the Puma, which is found from Canada to Patagonia, and which is larger than the largest dogs, and whose color is pale brownish-yellow, finely mottled by dark tips to the hairs; and such also are the Ocelot and Yaguarundi, cats found from Texas to South America; and such, of course, is the domestic cat, originally from the forests of the East, but now found all over the world in company with man. All the true Cats belong to the genus *Felis*.

The cats known as Lynxes have the tail very short, and they have one molar less than the true cats, in each side of the upper jaw. As examples of this kind, we may mention the Canada Lynx, about forty inches in length, and of a grayish hoary color waved with black, and the ears tipped with a pencil of black hairs; and the American Wild-Cat (*Lynx rufus*), which is about thirty inches long, and of a pale rufous color overlaid with grayish, and whose ear is black on the outside and has a white patch, and whose tail has a black patch above at the end.

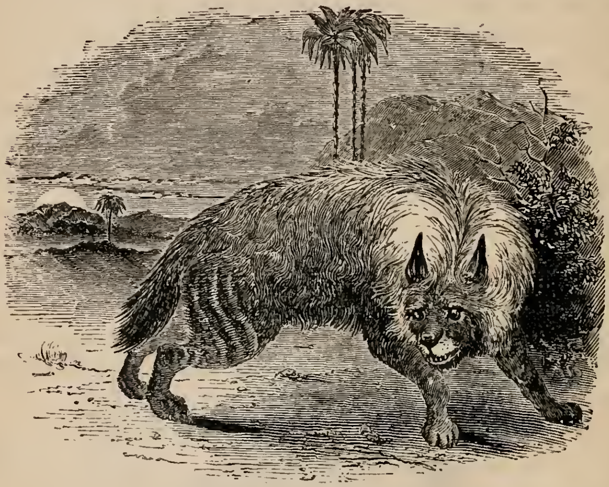
FIG. 82.



Canada Lynx, *Lynx canadensis*, Rafinesque.

Of all the Carnivora probably none can be regarded as uglier, in their general appearance, than the Hyenas or Hyenadæ. They have the fore legs longer than the hind ones, the claws non-retractile, the feet four-toed, and the tongue rough. Their premolars are very large and blunt; and these animals are able to crush the bones of very large animals, and swallow the fragments without masticating them. So powerful are the muscles of the neck and jaws that it is next to impossible to wrest anything from between their teeth.

FIG. 83.



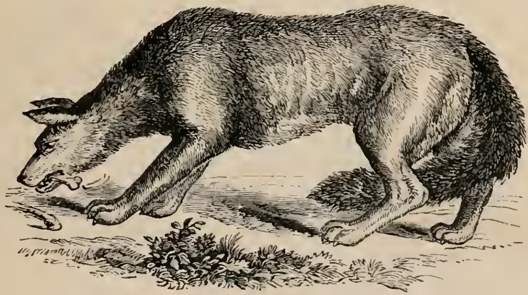
Hyena, *Hyena vulgaris*, Buffon.

Hyenas live in caves, are nocturnal in their habits, are extremely voracious, and feed chiefly upon prey which they find dead. They are emphatically the scavengers among the Carnivora. They belong to Africa and Asia, and are about five feet in length. Bones of Hyenas have been found in caves in many places in England and on the continent of Europe; they are bones of extinct species.

The Civets are small carnivorous animals of the average size of the domestic cat, but more elongated, and with a more pointed muzzle, and with a long tail. In most cases the feet are digitigrade, with hairy soles and retractile claws. Civets secrete in a sort of pouch or gland a substance formerly much used in perfumery, and which was long an important article of commerce. They belong to the Old World, and constitute the family Viverridæ.

The Dogs, Wolves, Foxes, and Jackals are representatives of the Carnivora which constitute the family known as the Canidæ. They have a rather long body, a more or less elongated and pointed muzzle, a smooth tongue, and the fore feet five-toed and the hind ones four-toed. Of all mammals the dog is the only one that has followed man into every quarter of the world. The varieties are exceedingly numerous; all, however, have the tail recurved. The origin of the Dog is uncertain; some naturalists considering this animal a modified wolf, and others a modified jackal.

FIG. 84.



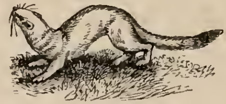
Wolf, *Canis occidentalis*, of authors.

The Wolves have the tail straight, that is, not recurved, and more or less bushy. They are crafty, ferocious, and greedy; feeding upon whatever they can kill, and also gorging themselves upon the bodies of dead animals, which they scent at great distances. They hunt in packs, and are thus able to overpower animals which singly they could not master. In newly-settled districts wolves often make great havoc among sheep, calves, and other domestic animals.

The Foxes are at once distinguished by their slender and pointed muzzle, large bushy tail, and elliptical pupil of the eye. Foxes excel all the other members of the Dog family in cunning and craftiness. The Red Fox, of a reddish-yellow color, is our common species; the Cross Fox and the Black or Silver Fox are regarded as mere varieties of the first-named.

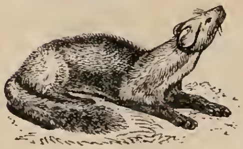
Other representatives of the Carnivora are the Fishers, Martens, Sables, Weasels, Minks, Gluttons, Skunks, Badgers, Otters, etc., all of which belong to the great family of the Mustelidæ, and agree in a general way in having a long, slender body and five-toed feet, and in having glands which secrete a liquid of the most disagreeable odor.

Fig. 85.



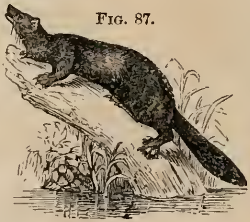
Little Ermine or Weasel,
Putorius Richardsonii, Bonaparte.

Fig. 86.



American Sable.
Mustela americana, Turton.

Fig. 87.



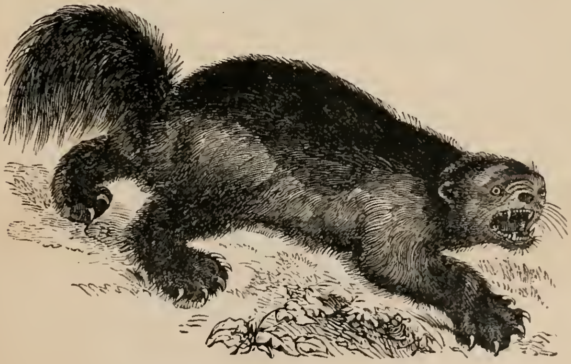
Mink, *Putorius vison*,
Richardson.

Those known as Martens (*Mustela*) have thirty-eight teeth, and are arboreal in their habits. Such are the Fisher, which is two feet long to the tail, and of a black color; the American Sable, which is seventeen inches long to the tail, of a reddish-yellow, clouded with black, and which yields the highly prized furs known as Hudson Bay Sable; and the Siberian Sable, so celebrated for furnishing the costly fur known as Russian Sable.

The Weasels and Minks have the body exceedingly slender, and thirty-four teeth. The Weasels are brown in summer and white in winter, with the tip of the tail black. The costly fur known as ermine is furnished by a weasel of the cold parts of Europe and Asia. Weasels are all very small animals, having the body only from six or eight inches to less than a foot in length. Minks are about seventeen inches long to the tail, and their color is dark-brown or black in summer and winter. Both Weasels and Minks belong to the genus *Putorius.*

The Wolverines (*Gulo*) have a much stouter body than

FIG. 88.

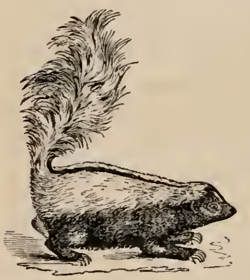


Glutton or Wolverine, *Gulo luscus*, Sabine.

the typical members of the Mustelidæ, and have a very bushy tail. Our only species is found in the cool and cold portions of our country, and is about three feet long to the root of the tail, and the general color is dark-brown; the tail, legs, and under parts are black. It is very troublesome to the sable-hunters, by breaking up their wooden traps and destroying the bait, or game; it also destroys *caçhes* of provisions.

The Skunks have a pointed nose, a bushy tail, and feet fitted for digging. They are well known by the intolerable odor which they emit when disturbed. They are nocturnal, and feed upon beetles and other small animals, and upon eggs. They walk on most of the sole of the foot, with the back much curved and tail erect. Five species are found in North America.

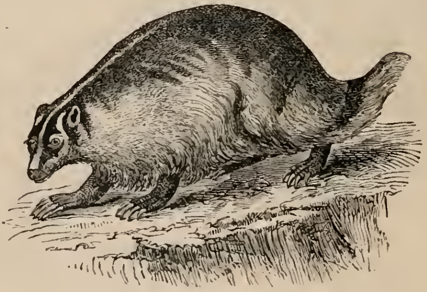
FIG. 89.



Skunk, *Mephitis chinga*, Tiedman.

The Badgers have a stout, robust, depressed body, very short tail, much enlarged fore claws adapted for digging. Our only species is found in the western and north-

FIG. 90.

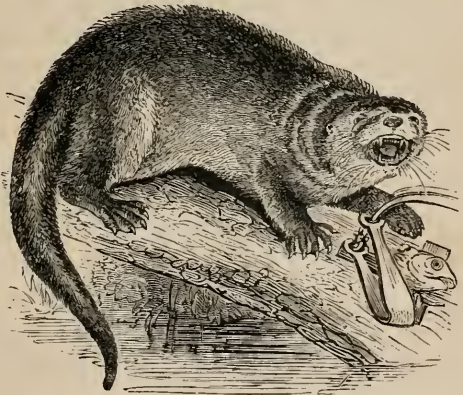


American Badger, *Taxidea americana*, *Waterhouse*.

western portions of the country, and its body is a little less than two feet long, and the general color is grayish. Badgers live in burrows, and dig with astonishing rapidity.

The Otters have a flat head, elongated body, short, palmated feet, and depressed tail. They are aquatic, and feed upon fish, which they pursue with such dexterity that few are swift enough to elude them. Otters have a singular and amusing habit of sporting. Selecting a bank of snow in winter, or a clayey bank in summer, they scramble to the top, and then slide head foremost to the bottom. If their sliding-place leads into the river, as is generally the case, they go plump into the water, whence they quickly come forth again to repeat an operation which evidently gives them great satisfaction. The American Otter is about three feet long to the tail, and the color is brown above, slightly lighter beneath; and the fur is of two kinds, one long, somewhat coarse, and scattered, the other shorter, fine, and dense.

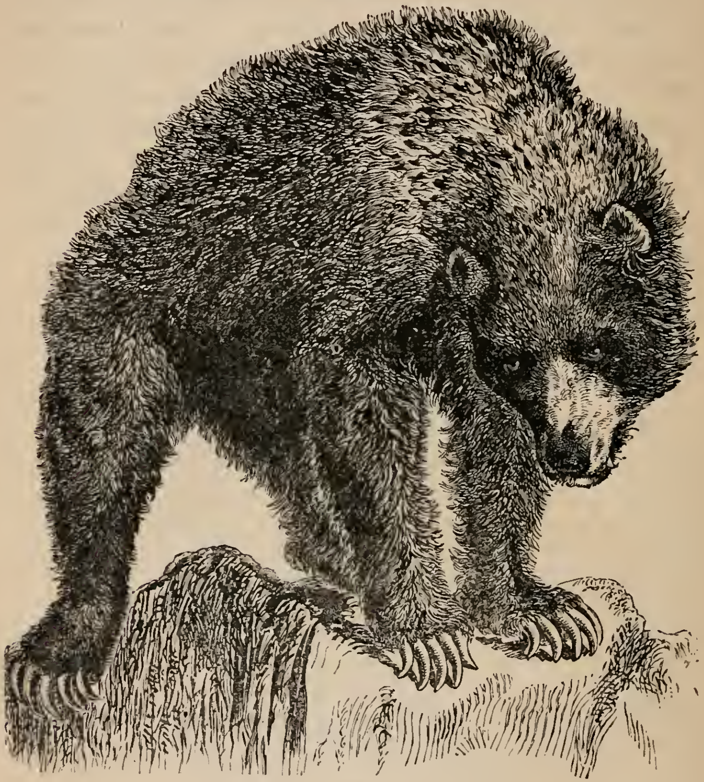
FIG. 91.



American Otter, *Lutra canadensis*, Sabine.

Passing from the more typical members of the Carnivora, we come now to the Bears and Raccoons, which, though being carnivorous animals, feed more or less upon vegetable food. They are true plantigrade carnivora—those which walk on the whole sole of the foot. They are five-toed. Many of the species are ready climbers. Those which inhabit cold climates pass the winter in a torpid state.

FIG. 92.

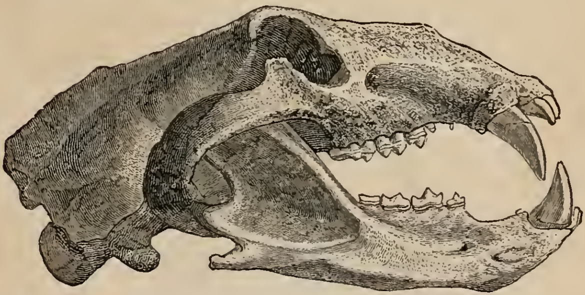


Grizzly Bear, *Ursus horribilis*, Ord.

The true Bears or Ursidæ have a large, thick body, broad head, short tail, wholly plantigrade feet, with naked soles and long nails. The dental formula is, incisors $\frac{3-3}{3-3}$, canines $\frac{1-1}{1-1}$, premolars $\frac{4-4}{4-4}$, molars $\frac{2-2}{3-3}$.

The Grizzly Bear, of the plains of the Upper Missouri, and of California, is eight feet in length, the hair coarse, and the color grizzly. The feet are very large, and the fore claws are twice as long as the hind ones, and on the largest individuals are six inches in length. This animal is one of the most powerful and most ferocious of all the Bear tribe. When excited by hunger or anger, it attacks man or any animal it can overtake. Even the Bison sometimes falls a victim to its ferocity, and is dragged away whole to be eaten at leisure. The Brown Bear of Europe (Fig. 93) is a species closely allied to the Grizzly.

FIG. 93.

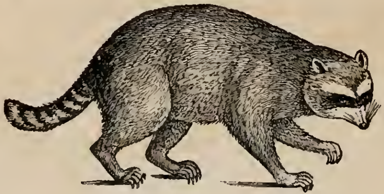


Skull of Brown Bear, *Ursus arctos*, Linnæus.

The Black Bear, of North America generally, weighs from two hundred to four hundred pounds, is of a uniform black or deep brown color, and the hair is comparatively soft and glossy. Under ordinary circumstances this bear is not very ferocious. The Polar Bear is eight feet long, and attains the weight of one thousand to fifteen hundred pounds. It is snow-white, wholly carnivorous, and feeds upon seals and other animals.

The Raccoons or Procyonidæ have a pointed muzzle, and moderately long tail, and they are less than two feet in length, to the tail. The Raccoons are nocturnal in their habits, and feed upon roots, birds, and other small animals. They are easily tamed, and are said to dip their food in water before eating it.

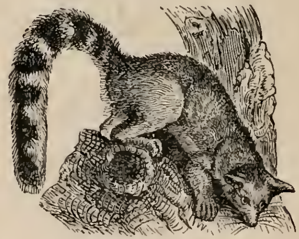
FIG. 94.



Common Raccoon, *Procyon lotor*, Storr.

In taking leave of the FISSIPED (Latin *fissus*, split, and *pes*, *pedis*, foot) carnivora, as all those already noticed are sometimes called, we may mention the Civet Cats or Bassaridæ, animals somewhat raccoon-like in form. One species is found from Texas to California, and is about the size of the domestic cat, but more slender; its color above is brownish-yellow mixed with gray beneath; the tail is white and has six to eight black rings. It is arboreal, easily tamed, and a favorite pet with the miners.

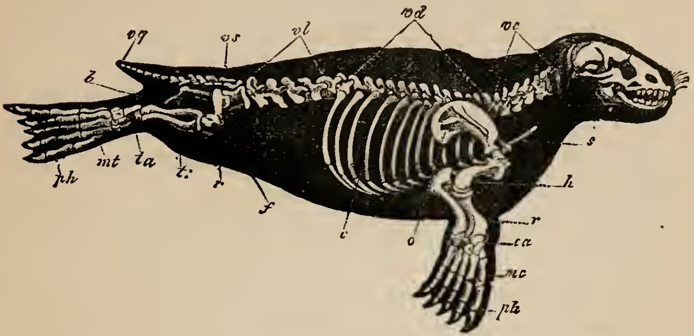
FIG. 95.



Civet Cat, *Bassaris astuta*, Lichtenstein.

The carnivorous mammals which have their locomotive organs paddle-like or fin-like, and which have their home

Fig. 96.



Skeleton of a Seal.

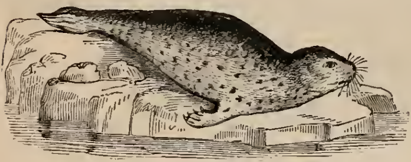
vc, cervical vertebræ; *vd*, dorsal vertebræ; *vl*, lumbar vertebræ; *vs*, sacral vertebræ or sacrum; *vq*, caudal vertebræ; *c*, ribs; *s*, sternum; *o*, scapula; *h*, humerus; *r*, radius; *ca*, carpus; *mc*, metacarpus; *ph*, phalanges; *p*, pelvis; *f*, femur; *r*, rotula.; *t*, tibia: *ta*, tarsus; *mt*, metatarsus.

in the sea, are called Pinnipeds or Pinnigrades, as stated on page 81. They are the Seals and the Walrus.

The Eared-Seals or Otariadæ—named from the Greek *otus*, an ear—have a rather stout body and distinct external ears. Their fore limbs are situated far back, and the digits are destitute of nails. The hind feet have the toes of nearly equal length, and terminated with long, cartilaginous flaps, and the three middle toes are provided with nails. The dental formula is, incisors $\frac{3-3}{2-2}$, canines $\frac{1-1}{1-1}$, molars $\frac{5-5}{5-5}$ or $\frac{6-6}{5-5}$. This family has its principal representatives in the Pacific Ocean. Some of its members, as the Northern Fur-Seal or Northern Sea-Bear, are seven or eight feet long, and attain a weight of five to seven hundred pounds; and others, as the Sea-Lion, are twelve or thirteen feet long, and attain a weight of eighteen hundred pounds! The "Sea-Bear" yields the highly prized seal fur.

All the Common Seals belong to a family named the Phocidæ. They are comparatively long and slender, and have the external ears obsolescent, the anterior legs smaller than the posterior, and the anterior and posterior feet provided with claws. The Phocidæ include some genera in which the incisors are $\frac{6}{4}$; others in which they are $\frac{4}{4}$; and others in which they are $\frac{4}{2}$. The canines are normally developed, and the molars are generally $\frac{5-5}{5-5}$. The seals of this family are from three to twenty feet in length, and are remarkable for the beautiful and intelligent expression of their eyes, and also for their docility when in a state of captivity.

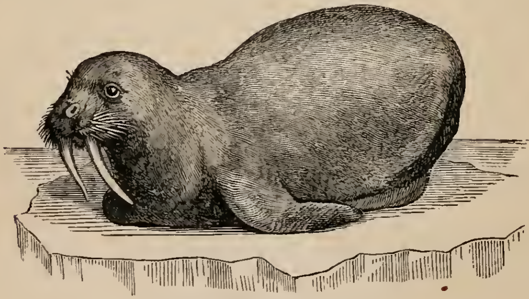
Fig. 97.



Common Seal, *Phoca vitulina*, Linn.

The Walrus of the Arctic Seas is the only living representative of the family Rosmaridæ. It is seal-like in its general appearance, but is especially remarkable on account of its enormously developed upper canine teeth, which extend downwards in the form of large tusks. Its body is very large, equaling in size that of the largest ox, and is covered with short brown hair.

Fig. 98.



Walrus, *Rosmarus obesus*, Gill.

SUB-SECTION V.

THE ORDER OF UNGULATA OR HOOFED ANIMALS.

The mammals which belong to the Order of Ungulata, have the terminal joints of the toes encased with thick nails called hoofs, and the hinder part of their feet covered with hairy skin continuous with the general integument of the animal. These mammals have never more than four toes completely developed; and they have no clavicles. The name of this order comes from the Latin *ungula*, a hoof.*

The incisor teeth of the Ungulates are normally six in the upper jaw, and six in the lower; but in many cases those of the upper jaw are fewer than six; and incisor teeth are wholly wanting in the upper jaw of the Oxen, Antelopes, Deer, Sheep, and Goats—those of the lower jaw, together with the two canines, making a series of eight teeth similar in appearance, shutting against a hard pad above.

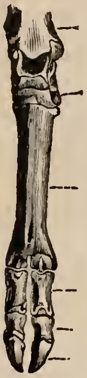
Many of the members of the Ungulates—as the Camels, Giraffe, Oxen, Antelopes, Sheep, Goats, Deer, Hippopotamus, and Hogs, and many fossil forms, as those known as Sivatherium, Oreodon, Anoplotherium, etc.—have each of their feet terminating in an even number of toes, and hence are called Even-toed ungulates or ARTIODACTYLS, from the Greek *artios*, even, and *dactylus*, a finger. And it may be added here that the third and fourth toes of the

---

* The Ungulata include all the animals formerly comprised in the old groups *Pachydermata* and *Ruminantia*, excepting only the Elephant and its allies, and Hyrax.

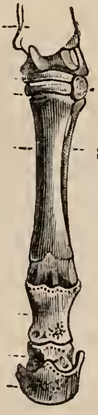
Artiodactyls are the two principal ones, and that they are so nearly of the same size that they appear like a single hoof cleft in the middle; and, hence, these animals are often called cloven-footed animals.

FIG. 99.


Tibia.
Tarsus.
Metatarsus or Canon bone.
Proximal phalanx or great pastern.
Middle phalanx or little pastern.
Distal phalanx.

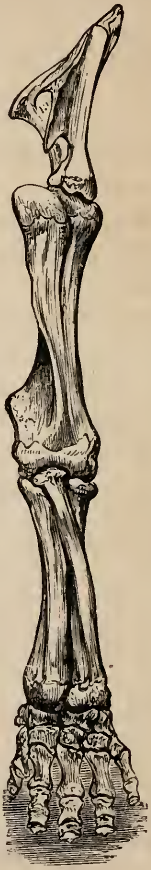
Foot of an Artiodactyl—Deer.

FIG. 100.


Tibia
Tarsus
Metatarsus or Canon bone.
Styloid bone—a rudimentary digit.
Proximal phalanx
Middle phalanx
Distal phalanx

Hind foot of a Perissodactyl—Horse.

FIG. 101.

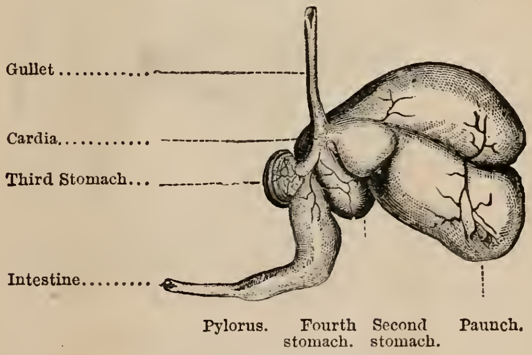


Right fore leg of a Perissodactyl—Elephant.

On the other hand, many ungulates—as the Horses, Rhinoceroses, Tapirs, etc., and many fossil forms called Macrauchenia Paleotherium, etc.—have an odd number of toes, and, hence, are called PERISSODACTYLS, from the Greek *perissos*, uneven and *dactylus*, a finger. In these it is the third digit which is the most prominent one.

Many of the Artiodactyls chew the cud, that is, masticate their food a second time, and, hence, are called the Ruminantia. Such are the Camels, Giraffe, Oxen, Antelopes, Sheep, Goats, Deer, etc. In accordance with this faculty, these animals have the stomach composed of four compartments (see Fig. 102), each having a special function. The food being partially chewed is passed into the largest stomach or paunch; thence into the second stomach, or honey-comb, where it is moistened and compressed into pellets, which afterwards ascend to the mouth and are rechewed mainly while the animal is at rest; the remasticated food descends directly to the third stomach or leaflet, thence to the fourth stomach or caillette, which

FIG. 102.



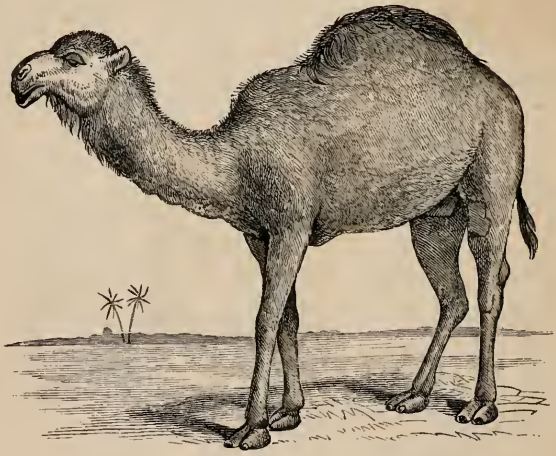
Stomach of a Ruminant—Sheep.

is the true organ of digestion, corresponding to the simple stomach of mammals in general.

The Even-toed ungulates, or Artiodactyls, have the molars each with two double crescent-like folds, whose convex surfaces are inside; and the canines of the lower jaw—except in Camelidæ—are in the same row with the incisors, and closely resemble them.

Of all the Ungulates, few, and perhaps none, are more remarkable than the Camels and the Llamas, which constitute the family of Camelidæ. The true Camels (*Camelus*) have the toes united below nearly to the point by a common sole, and the back furnished with humps of fat. They have canine teeth in both jaws—those of the lower jaw being specialized and different from the incisors—two pointed teeth in the place of incisors in the upper jaw, six incisors in the lower jaw, and eighteen to twenty molars. Camels are natives of Central and Southwestern

FIG. 103.

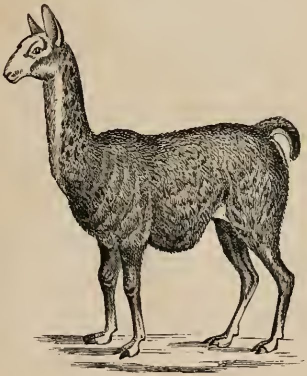


One-humped Camel, *Camelus dromedarius*, Linnæus.

Asia, and are as indispensable to the merchant and traveler in crossing the deserts of the Old World, as are vessels for crossing the ocean. Their wonderful power of going a long time without drinking is due to the large number of cells on the walls of the paunch, in which is stored an extra supply of water. Camels are about ten feet long and eight feet high.

The Llamas (*Auchenia*) are confined mainly to the Andes, and are somewhat larger than sheep. Besides being smaller than the Camels, they further differ from them in having no humps, and in having the two toes entirely separate.

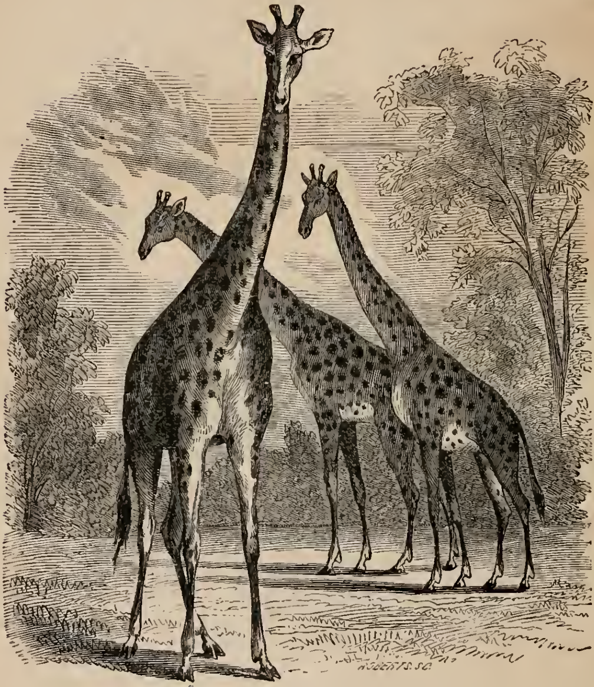
Fig. 104.



Llama, *Auchenia llacma*, Linn.

Another very remarkable form of artiodactyl ungulates is seen in the Giraffe, whose neck is so long that its head is sixteen or eighteen feet from the ground! Both sexes have short conical horns which are covered with a hairy skin, and which are never shed. By its whole structure the Giraffe is fitted for subsisting upon food which grows high above the surface of the ground. By means of its long neck and curious prehensile tongue it is able to secure leaves which grow at the height of twenty feet! Giraffes have their home in the deserts of Africa.

FIG. 105.

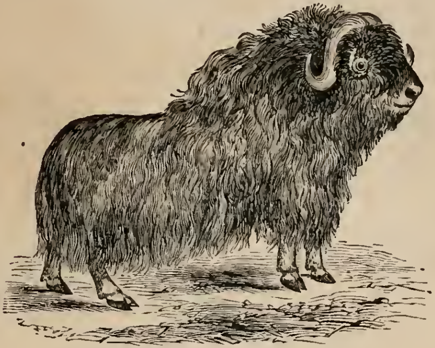


Giraffe, *Camelopardalis giraffa*, Cuvier.

Many of the artiodactyl ungulates—as the Oxen, Musk Ox, Antelopes, Goats, and Sheep, which together constitute the great family of the Bovidæ or Cavicornia—have permanent hollow horns which ensheathe a process of the frontal bone, the process being a sort of core to the true horn, which is the same, essentially, as hair. The Oxen or Bovinæ have the horns round.

Of the Oxen few are more remarkable than the Musk Ox of the Barren Grounds of North America. This curious animal is about as large as a two-year-old cow, and the body is covered with long brownish black hair.

FIG. 106.

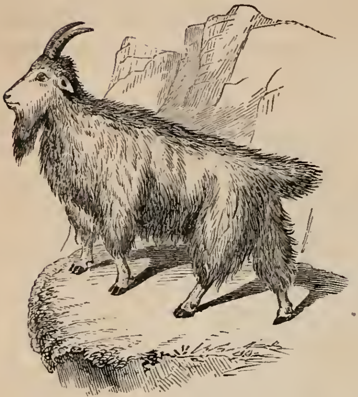


Musk Ox, *Ovibos moschatus*, Blainville.

As examples of the typical or true oxen (*Bos*), we may mention the domestic ox, and the Buffalo or Bison of our Western plains, which attains the size of a large domestic ox. Here also belong the Aurochs of the Caucasus, the Cape Buffalo of South Africa, and the Arni of India; the last with horns ten feet from tip to tip.

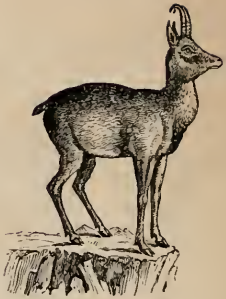
The artiodactyls which have their horns rounded, variously curved, ringed, and black, are called Antelopes (*Antilope*). Of these nearly a hundred species are known, varying in size from the light and graceful Gazelle (Fig. 109) of Northern Africa—not larger than a fawn—to those like the Eland of Africa, which is as bulky as a large ox. Of these all but one, which inhabits North America, and the Chamois (Fig. 108) and one other which inhabit

FIG. 107.



Mountain Goat, *Aplocerus montanus*, Richardson.

FIG. 108.



Chamois, *Antilope rupicapra*, Linn.

FIG. 110.

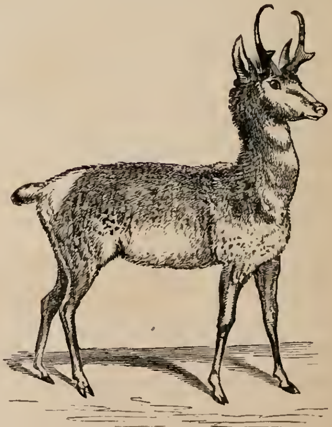
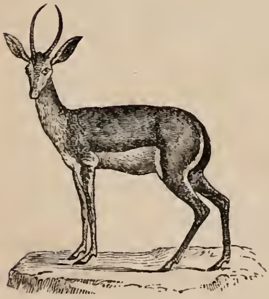


FIG. 109.



Gazelle, *Antilope dorcas*, Linn.

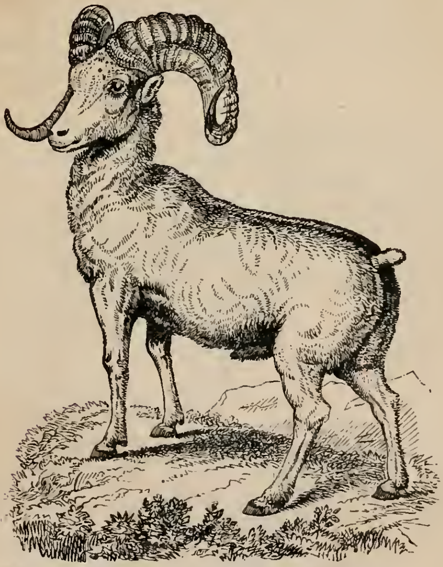
Pronghorn Antelope, *Antilocapra americana*, Ord.

Europe, belong to Southern Asia and to Africa, but mainly to Africa.

Our so-called Mountain Goat (Fig. 107), is an antelope. It inhabits the Rocky Mountain regions, has jet black horns, and is covered with long white hair.

The Goats (*Capra*), and Sheep (*Ovis*), differ from all other hollow-horned ungulates in having the horns angular. The former have their horns extending upward and backward; the Sheep have the horns directed backward, and then inclined spirally forward. Our only wild species, the Mountain Sheep of the Rocky Mountains, is larger than any of our domestic varieties, and is remarkable for its very large horns.

FIG. 111.

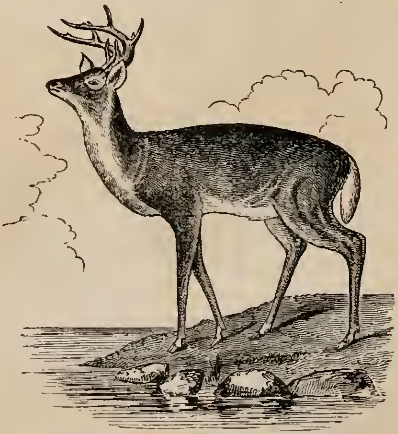


Mountain Sheep, or Big-horn, *Ovis montana*, Cuvier.

Passing now from artiodactyl ungulates which have permanent, hollow horns, we come next to the Pronghorn "Antelope" (Fig. 110), which differs from the true antelopes in the fact that its horns have a prong or branch, and are not permanent, but deciduous, notwithstanding that the horns have an osseous core similar to that found in the Bovidæ described above. It is therefore referred to a distinct family, the Antilocapridæ. The Pronghorn of our Western plains, is a beautiful animal, somewhat larger than our domestic sheep; its coarse hair is brown above, and the under parts and rump are white.

Quite different from all of the artiodactyl ungulates already named, are the Deer or Cervidæ. These have their horns solid and deciduous. Their so-called horns are at first covered with skin similar to that upon the rest of the head. At their base is a ring of bony tubercles, which, as they enlarge, compress and obliterate the blood-vessels

FIG. 112.

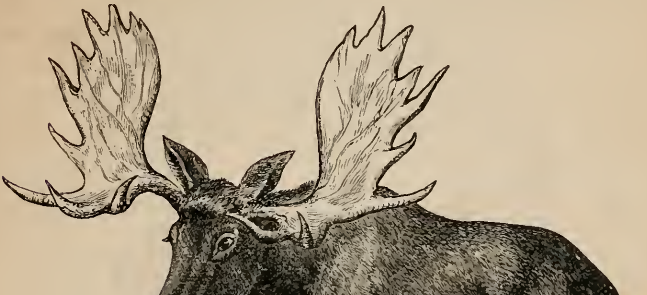


Virginia Deer, *Cervus virginianus*, Boddaert.

of that skin, and the latter becomes dry and peels off, leaving the horns bare. At length the horn separates from the cranium and falls off. Others, however, and larger ones, take their places, and these in turn are subject to the same changes. Thus the horns of these animals are shed and renewed periodically. Such horns are called *antlers*.

Some kinds of the deer, as the Elk of Europe, and the Moose (*Alces*) of Maine and Canada, and the Great Irish Elk (fossil), have broadly palmate horns—in the male—as

FIG. 113.

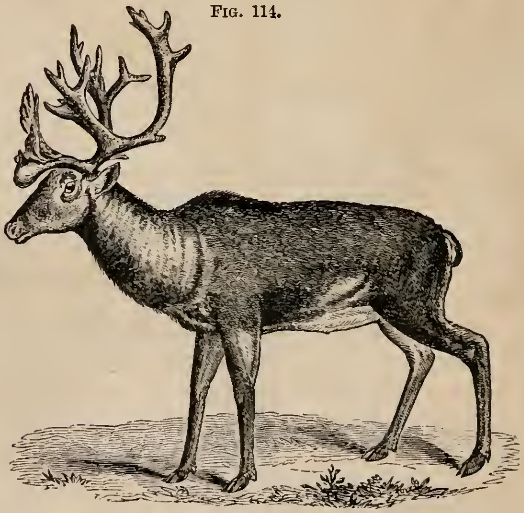


Moose, *Alccs americanus*, Jardine.

in Fig. 113. The Moose is the largest living member of the Deer family, quite equaling the horse in bulk, and standing very high.

Other kinds of deer, as the celebrated Reindeer of Lapland, and the Caribou or American Reindeer (Fig. 114), of North America, both belonging to the genus *Rangifer*, have the horns palmated at the tip, and present in both sexes. The Reindeer is about four and a half feet long, and three feet high.

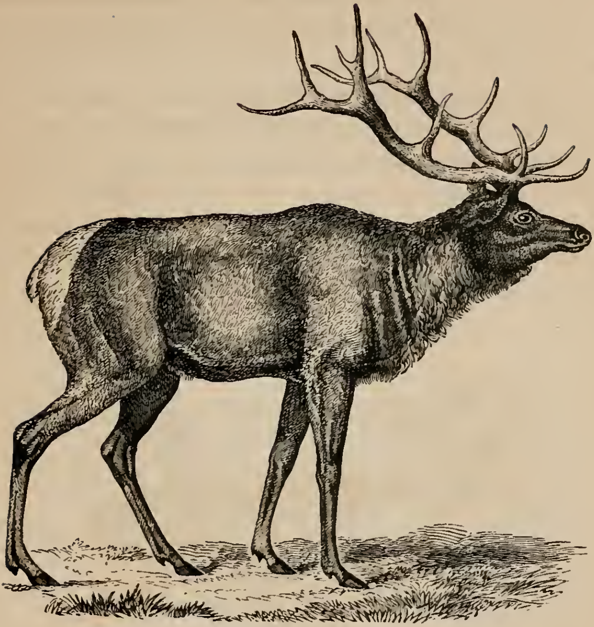
Fig. 114.



American Reindeer, or Caribou, *R. caribou*, Audubon and Bachman.

Still other kinds of deer, those of the genus *Cervus*, as the Virginia Deer (Fig. 112), and the American Elk or Wapiti (Fig. 115), have the horns more or less cylindrical or conical. The American Elk is found in the northwestern portions of the United States and northward, and is about as large as a horse, and is remarkable for its very long and much branched horns.

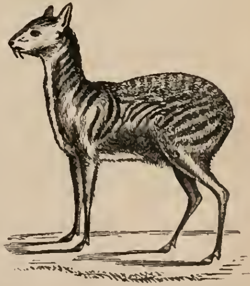
FIG. 115.



American Elk or Wapiti, *Cervus canadensis*, Erxleleben.

And lastly we may mention the deer which furnishes the well-known musk of commerce—the Musk Deer. This animal is destitute of horns; but the males have a long canine tooth in each side of the upper jaw. This animal is about the size of the common goat, has scarcely any tail, and is covered with coarse and brittle hairs. It inhabits Thibet and the adjacent countries.

FIG. 116.

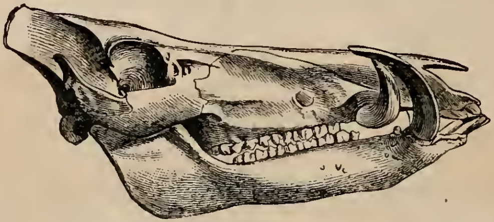


Musk Deer, *Moschus moschiferus*, Linn.

Passing by some living, and many fossil forms (as *Oreodon*, *Anoplotherium*, *etc.*,) we come to the Hippopotamus family, or Hippopotamidæ, whose principal representative inhabits the Nile and some other rivers of Africa. The Hippopotamus has an exceedingly massive body, as large as that of an ox, very short legs, large head, enormous muzzle, small eyes and ears, and short tail, and very large canine teeth.

And lastly, we may merely mention the bristle-bearing even-toed ungulates, as Hogs or Suidæ, Peccaries or Dicotylidæ, and their various allies—all of which are hog-like in their general appearance, and which have their nostrils in the end of the snout, and the latter terminating in a sort of disk or button well suited for rooting or turning up the ground.

Fig. 117.



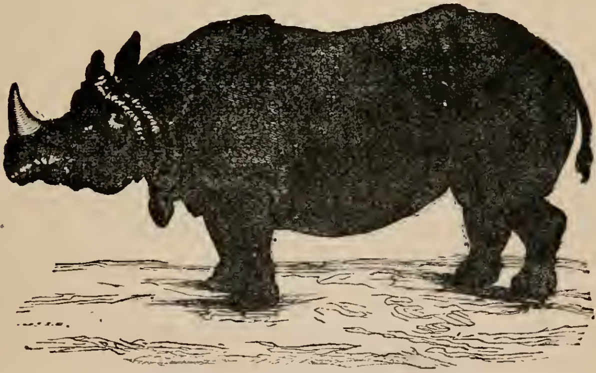
Skull of the Wild Boar, *Sus scropha*, Linnæus.

Of the Perissodactyls, first on the list come the Equidæ, or Horse, Ass, Zebra, and their immediate relations; animals which have only one apparent toe and a single hoof to each foot; although, under the skin, on each side of their metatarsus and metacarpus, there are spurs representing two lateral toes.

All the varieties of our present horses are from a stock indigenous to the Old World; but bones of horses have been found fossil in various parts of our country, and they show that North America had its own species of wild horses, and those of various sizes.

Comparing merely the external forms of the Horse and the Rhinoceros with each other, we would naturally regard them as very widely separated; but in reality no living form is regarded as nearer the horse than the Rhinoceroses, or Rhinocerotidæ, bulky animals which have stout legs, three-toed feet with hoofs of unequal size, and a very large muzzle, and whose body is covered with an exceedingly thick, tough, and naked skin, which lies in folds. They have also incisors in both jaws, and from the top of the muzzle, where the bones are very thick and strong, there arises a solid horn, sometimes two or three feet long, composed of agglutinated fibers essentially the same as hair. In some species there are two horns, the hinder one being situated on the frontal bone. The members of this family are the largest of all the land animals except the elephant, attaining a weight in some cases of 6,000 pounds. They

FIG. 118.

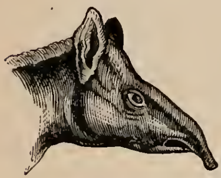


Indian Rhinoceros, *Rhinoceros indicus*, Cuvier.

inhabit Africa, Asia, and the Asiatic Archipelago. Their home is along marshy borders of lakes and rivers and in the jungles.

Some kinds of the Perissodactyls, as the Tapirs, or Tapiridæ, remind us a little of the elephants, on account of the fact that they have the nose developed into a proboscis; but the proboscis is much shorter than that of the elephant. As regards their feet, the Tapirs have four toes on each four foot, and three on each hind one, thus being in part artiodactyl and in part perissodactyl. One species is found in South America, and one in India. They are about as large as the ass, but with shorter legs.

FIG. 119.



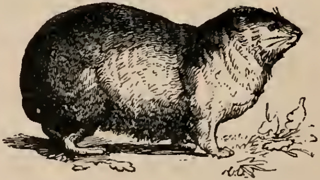
Head of Tapir.

SUB-SECTION VI.

THE ORDER OF HYRACOIDEA, OR DAMANS.

Very small animals, which Cuvier called rhinoceroses in miniature without a horn, make up the order Hyracoidea. They are covered with fur, are scarcely larger than rabbits, and are popularly known as Damans. They inhabit the rocky regions of Africa and Syria; and are often called Rock-Rabbits.

FIG. 120.



Daman, *Hyrax*.

The Damans have the lower surface of their feet furnished with pads; and four toes on each fore foot, and three on each hind one; and the terminal phalanges covered with hoofs. They have four incisors in the upper jaw, and four in the lower. Those of the upper jaw being long and curved; those of the lower straight.

SUB-SECTION VII.

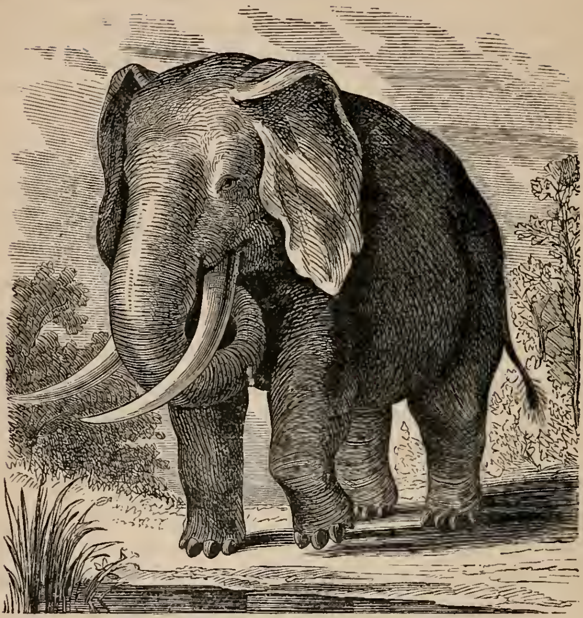
THE ORDER OF PROBOSCIDEA OR PROBOSCIDEANS.

This order includes the living and fossil Elephants, together with the extinct Mastodons and the Dinotheriums. The most striking characteristics of these animals are their enormous size, and their nose which is developed into an exceedingly long proboscis, and their incisor teeth which are developed into long tusks.

The legs of the Proboscideans are almost wholly outside of the abdominal integuments; and in standing, their knee-joint is straightened so that their femur and leg bones are in one and the same line. Their toes are five in number, and are encased in hoofs, so that by their feet they are closely allied to the true Ungulates.

As already indicated, one of the most remarkable features of the Elephant is the proboscis or trunk, a long, cylindrical organ composed of several thousand muscles and endowed with the most delicate sensibility, and terminated by an appendage which serves as a sort of finger. This trunk, agile and powerful, is at the same time the organ of smell, of touch, of prehension, and of defence. With it its possessor seizes everything he wishes to convey to his mouth, drink as well as food; thus obviating the necessity of a long neck, which would be inconsistent with the enormous head and heavy tusks, the latter

Fig. 121.



Elephant.

weighing sixty to one hundred pounds each. The tusks are simply the incisor teeth of the upper jaw enormously developed and modified. Elephants of the present day are confined to the warm regions of the Eastern hemisphere. They are seven to ten feet high, and ten to fifteen feet in length, and covered with thick, nearly naked skin. One distinctive characteristic of these animals is found in the grinders, the crown of which is deeply divided into transverse vertical plates, each consisting of dentine coated by enamel, and this by a bone-like substance which fills the spaces between the plates and cements them together. The grinders succeed each other from behind forward; and there is never more than one, or two partially, on each side of both jaws at the same time; for the series is in constant process of shedding and replacement. The total number of grinders which follow one another on each side of both jaws is seven, or at least six.

In both hemispheres the superficial deposits abound with bones of elephants which are now extinct. An elephant, covered with long, thick hair, and wholly unlike anything now living, was found encased in ice on the coast of Siberia. It was in such a state of preservation that dogs fed upon the flesh, although it is probable that it had been there thousands of years.

The *Mastodon* is an extinct proboscidean whose remains abound in the superficial accumulations of America, as well as in those of the Old World. In general appearance the Mastodon was much like the elephant, but differed from the latter in the grinders, the crowns of which are studded with large conical points. The Mastodon was vastly larger than the Elephants of to-day.

SUB-SECTION VIII.

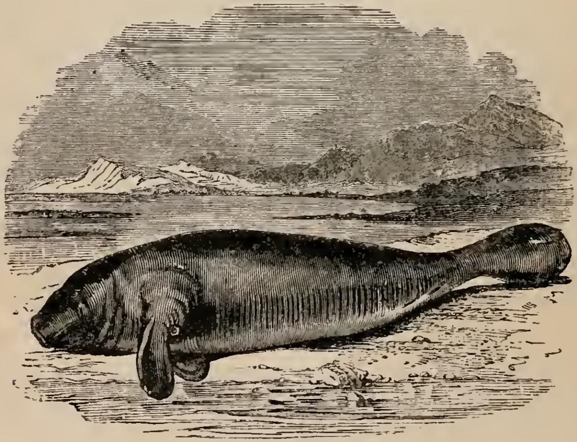
THE ORDER OF SIRENIA OR SIRENIANS.

The mammalia of this order are more or less fish-like, or more nearly whale-like, in general appearance, and are popularly known as Sea-Cows, Dugongs, and Stellers.

They are specially fitted for progression in the water. Their forward limbs are paddle-like, and they have neither hind limbs nor pelvis, and their tail is flattened horizontally. In these respects they are like the whales; and hence the Sirenia and Cetacea are sometimes grouped together, and the group thus formed is called the Mutilata.

The Sirenia, however, differ from the Whales in many respects, both in structure and in habits. The brain of the Sirenians is narrow; their neck is of moderate length, and its second vertebra has a tooth-like process; their only limbs, the forward ones, are moderately long, and flexed at the elbow; the mammæ are upon the breast; they have molar teeth with flat crowns adapted for grinding vegetation, and have corresponding herbivorous habits. They inhabit the warmer parts of the ocean, near the shores, and often ascend large rivers. They even leave the water and crawl upon the shore to feed upon the land vegetation; and this fact caused them to be called "Herbivorous Whales." They attain the length of ten to twenty feet.

Fig. 122.



Sea-Cow, *Manatus.*

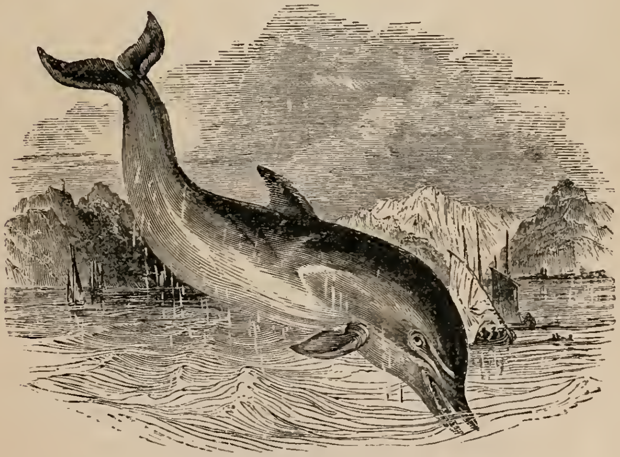
Some kinds of the Sirenians, as the Sea-Cows (*Manatus*), have the tail rounded; others, as the Dugongs (*Halicore*), and the Stellers (*Rhytina*), have the tail forked. Those of the last genus are without teeth.

SUB-SECTION IX.

THE ORDER OF CETACEA OR WHALES.

The name of this order comes from the Greek *ketos*, a whale. The Cetacea are mammalia which are somewhat fish-like in general appearance, and which are specially adapted for a constant residence in the water. They have their forward pair of limbs paddle-like; and they are wanting in hind limbs and pelvis—two small bones suspended in the flesh being the only vestiges of hind extremities. The Cetaceans progress mainly by means of their broad and horizontally flattened tail. They are

FIG. 123.



Dolphin, *Delphinus delphis*, Linnæus.

covered with a smooth skin, beneath which is a layer of fat called blubber. Their brain is broad, neck very short, and the second cervical vertebra is without a tooth-like process.

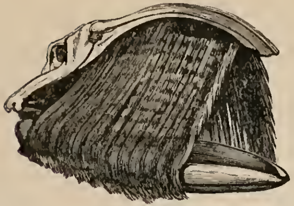
The breathing orifice of the Cetaceans, which corresponds to the nostrils of ordinary mammals, is situated in the top of the head, and is popularly called the "blowhole"; through this the water which has been taken into the mouth is sometimes "spouted" to a great height.

There is a group of extinct cetaceans which are called ZEUGLODONTS. Their remains abound in the Tertiary of Alabama, and show that these animals attained the length of eighty feet or more. The name is derived from the Greek *zeuglon*, a yoke, and *odous*, a tooth. They have teeth which are called yoke-shaped.

The DENTICETES or Toothed Whales—as the Dolphins, Sperm Whales, etc.—have true teeth, and no whale-bone or baleen. The Dolphins or Delphinidæ, of which there are many genera, such as Dolphins proper (Fig. 123), Porpoises, White Whale (*Beluga*), Narwhal (*Monodon*), etc., are from eight to twenty feet in length. The Sperm Whales, or Physeteridæ attain the length of sixty or seventy feet, and the head (Fig. 125), constitutes about one third of the whole animal. The well-known sperm oil and spermaceti are obtained from the last-named cetaceans. The Sperm Whales belong to the warm regions.

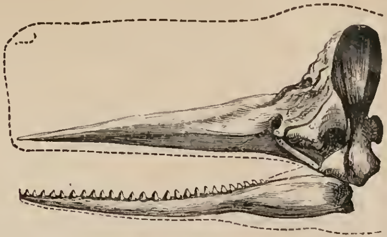
The MYSTICETES or Whale-bone Whales have the upper jaw provided with baleen or whale-bone (Fig. 126), and they have true teeth only before they are born! To this group belong the Finback Whales, or Balænopteridæ, which in most cases have a dorsal fin more or less developed, and which have short baleen. Some of the Finbacks attain

Fig. 124.



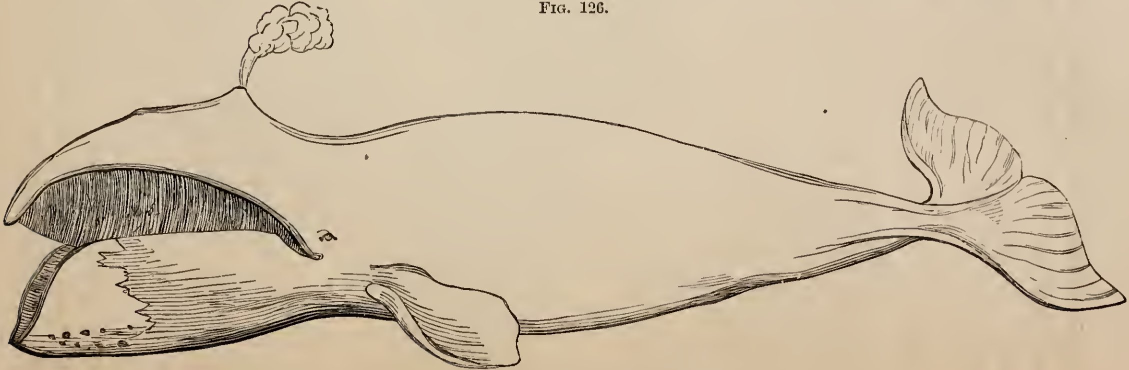
Skull of the Right Whale, showing the whale-bone.

Fig. 125.



Skull and outline of the Head of the Sperm Whale, *Physeter*.

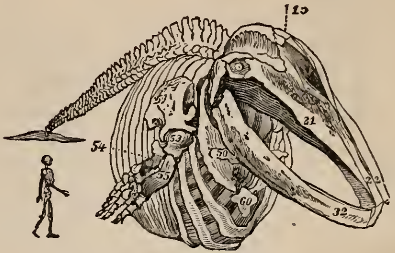
Fig. 126.



Right Whale, *Balæna mysticetus*, Linnæus.

enormous dimensions, even one hundred feet in length (Fig. 127). To the Mysticetes belong also the Right Whales or Balænidæ, which have the skull much arched and provided with long baleen or whale-bone plates finely fringed on their inner edges (Figs. 124, 126). This arrangement is adapted for securing the food of these whales, which consists of small marine zoöphytes, mollusks, and crustaceans. Swimming through schools of these little animals the whale engulphs myriads of them at once in its enormous mouth; and the water taken in with them is strained off through the baleen. Right Whales (Fig. 126) attain the length of seventy feet, and sometimes have blubber two or three feet in thickness; and the slabs of whalebone are eight to ten feet long; and a single individual yields from six hundred to nine hundred slabs on each side of the mouth! The Right Whales belong to the cold regions.

FIG. 127.



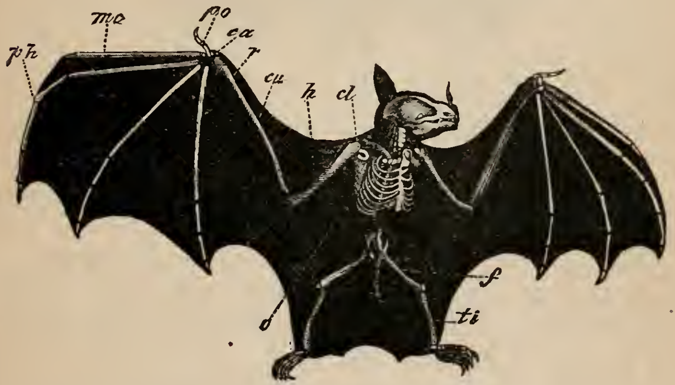
Fore-shortened view of Skeleton of a Whale, *Balænoptera boops*, showing its relative size as compared with Man.

SUB-SECTION X.

THE ORDER OF CHIROPTERA OR BATS.

The mammals of this order have been named Chiroptera because their anterior locomotive members are specially adapted for flight. The name is derived from two Greek words, *cheir*, a hand, and *pteron*, a wing. The bones of their forward locomotive appendages are much elongated, and sustain a fold of skin or membrane arising from the sides of the neck and body, and extending backward on the hind extremities, the whole forming wings of great extent of surface, thus enabling these animals to fly long and rapidly, and to execute movements as varied and complicated as those of birds.

FIG. 128.



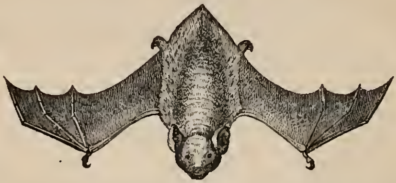
Skeleton of a Bat.

o, scapula; *cl*, clavicle; *h*, humerus; *cu*, cubitus or ulna; *r*, radius; *ca*, carpus; *po*, thumb; *mc*, metacarpus; *ph*, phalanges; *f*, femur ; *ti*, tibia.

Bats are nocturnal in their habits, and during the day remain in caves, hollow trees, or other dark places, suspended by their hooks, or by the nails of their hind feet. In cold and temperate regions they pass the winter in a state of lethargy. Although their eyes are very small, their large ears and broad wings possess such a delicate sensibility that bats are enabled to fly unharmed through the most winding and complicated passages, and that, too, even after their eyes have been destroyed.

Their teeth vary in number from 30 to 38; the canines are always present; and in most species the molars have numerous sharp points. The Chiroptera, together with the three succeeding orders—Insectivora, Rodentia, and Edentata—have the brain smooth, that is without convolutions.

FIG. 129.



Hoary Bat, *Lasiurus pruinosus*, Say.

All of our common bats (Fig. 129), as well as the Vampires of tropical America, feed upon other animals; and all excepting the Vampires, which are believed to suck the blood of the larger mammalia, feed upon small animals, mainly insects, which they capture while flying. Hence all these bats have been called Animalivora or animal devourers, a group equivalent to the sub-order of INSECTIVOROUS Bats.

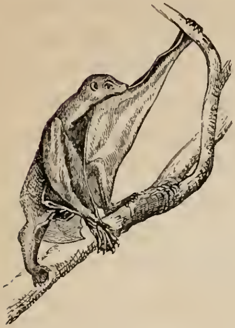
On the contrary, the Kalong Bat of Java—having a head like that of a fox, and an expanse of wings of more than four feet!—and other similar bats of India and Africa, feed wholly or partly upon vegetable food, and hence are called the FRUGIVOROUS Bats.

SUB-SECTION XI.

THE ORDER OF INSECTIVORA OR INSECT-EATERS.

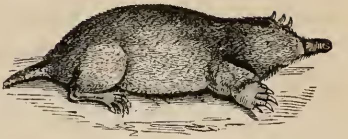
The mammalia of this group feed wholly upon worms and insects, and hence are called the Insectivora. Thus

FIG. 130.



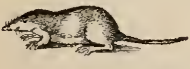
"Weasel-ape," *Galeopithecus.*

FIG. 131.



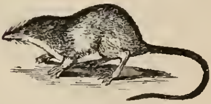
Common Mole, *Scalops aquaticus,* Cuv.

FIG. 132.



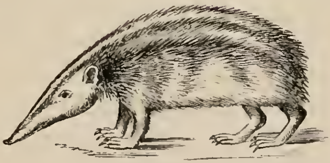
Thompson's Shrew.
Sorex Thompsonii, Baird.

FIG. 133.



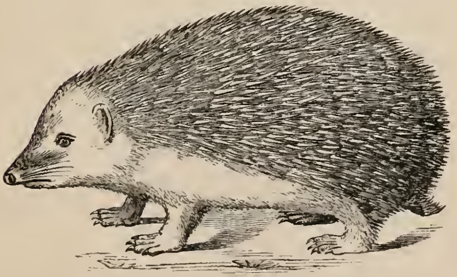
Water Shrew.
Neosorex navigator, Cooper.

FIG. 134.



Tenrec, *Centetes semi-spinosus,* Cuvier.

FIG. 135.



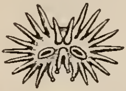
Hedgehog, *Erinaceus europæus,* Linnæus.

they live upon other animals, and in this respect they are like the Carnivora already described. But while they are analogous to that group, they differ from true carnivorous mammals in many important respects. They are not true flesh-eaters, but feed, as above stated, upon the smaller and weaker forms of animal life.

The Insectivora are the animals known as the Galeopithicus, Shrews, Moles, Hedgehogs, etc., most of which are exceedingly small, and the largest of which are not so large as the domestic cat; the Hedgehogs (Fig. 135), being the largest animals of the whole order.

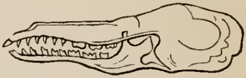
The teeth of the Insectivora are of three kinds, incisors, canines, and molars; and the latter are studded with acute points.

FIG. 136.



Star-nosed Mole,—end of Muzzle.

FIG. 137.



Skull and Teeth of an Insectivorous Animal—Star-nosed Mole, *Condylura cristata*, Illiger.

The Insectivorous bat-like mammal known as the Galeopithicus (Fig. 130), of the Indian Archipelago, represents a group called the DERMOPTERA, a name from the Greek *derma*, skin, and *pteron*, a wing. This curious animal is about the size of a cat, and lives upon trees.

The Moles or Talpidæ (Figs. 131, 136, 137), have the body stout, and the feet greatly expanded and fitted for digging in the ground. Their eyes are extremely minute and fur very thick and soft.

The Golden-green Moles or Chrysochlorididæ, of Africa, furnish us with the only example of a mammal with splendid metallic tints like those which adorn so many kinds of birds, fishes, and insects.

The Hedgehogs or Erinaceidæ (Fig. 135), have a short body covered with spines or stiff bristles, and the tail short or wanting. The skin of the back is so furnished with muscles that the animal can assume nearly the shape of a ball, presenting bristles on all sides. The European Hedgehog is smaller than a common cat.

The Tenrecs or Centetidæ (Fig. 134), are somewhat similar to the Hedgehogs, but they have a slender body, and they cannot so completely assume the form of a ball. They inhabit Madagascar, and although in a tropical climate are said to pass three months of the year in a state of lethargy.

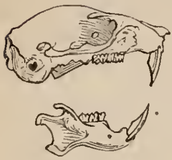
In the cool and cold regions there are many animals that pass into a torpid condition during the coldest part of the year,—the season least favorable for securing food. And while in this state their physiological conditions seem to approximate those of cold-blooded animals. The Hedgehog and Bat fall into so deep a torpor that no sign of breathing can be detected; and in the Bat's heart the pulsations fall from 200 in a minute to 30 in a minute, during torpidity.

SUB-SECTION XII.

THE ORDER OF RODENTIA OR GNAWERS.

This Order includes all mammalia which are specially fitted for gnawing, as Rats, Mice, Dormice, Gophers, Beavers, Squirrels, Porcupines, Agoutis, Chinchillas, Guinea Pigs, Hares, etc. The name comes from the Latin *rodere*, to gnaw. Linnæus called it the order of Glires, from the Latin *glis*, a dormouse. The Rodents are mostly small animals, the Beavers being the largest of all, with the single exception of the Capybara (*Hydrochærus*), an aquatic rodent about three feet long and with a bulky body, which is found along the rivers in South America.

FIG. 138.

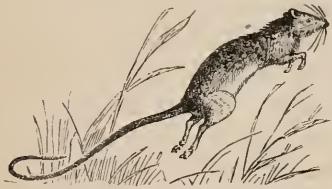


Skull and teeth of a Rodent.

The Rodents are readily distinguished by their teeth. In each jaw they have two chisel-shaped incisors, between which and the molars there is a wide space without teeth, canines being wanting. The incisors are covered with enamel only in front, so that their posterior edges wear away faster than the anterior edges, thus always keeping these teeth sharp, however much they are used; and they grow at the base as fast as they wear away at the summit. The lower jaw is articulated with the skull in such a manner that the jaws have no horizontal motion, except backwards and forwards as is requisite in the act of gnawing. The enameled ridges of the molars are transverse, thus in opposition to the horizontal forward and backward motion of the jaw, and exactly adapted to the process of trituration. The form of the Rodentia is generally such that the hind parts considerably exceed the forward parts; most kinds are thus adapted to leaping instead of walking. The brain of the Rodents is smooth (Fig. 66), that is, without convolutions.

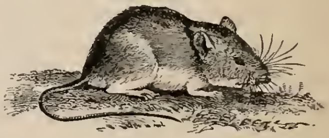
Some kinds of the Rodentia, as the Jerboas or Dipodidæ of Asia and Africa, and the Jumping Mice or Jaculidæ (Fig. 139), of this country, have the tail and hind legs

FIG. 139.



Jumping Mouse, *Jaculus hudsonius*, Baird.

FIG. 140.



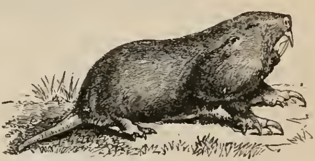
White-footed Mouse, *Hesperomys leucopus*, Wagner.

very long. The Jumping Mouse (Fig. 139), is about three inches long, and the tail six inches. It progresses by long and rapid leaps. In winter it hibernates.

The Rats and Mice or Muridæ constitute the most numerous family; the species in all countries, numbering at least three hundred!

Some kinds of the Rodents, as the Kangaroo Rats or Saccomyidæ have large external cheek pouches, and a slender body; others as the Pouched Gophers or Geomyidæ have large external cheek pouches and a thick body. The species here represented is of the latter family. It is found in the Western States and is eight inches long, besides the tail.

FIG. 141.

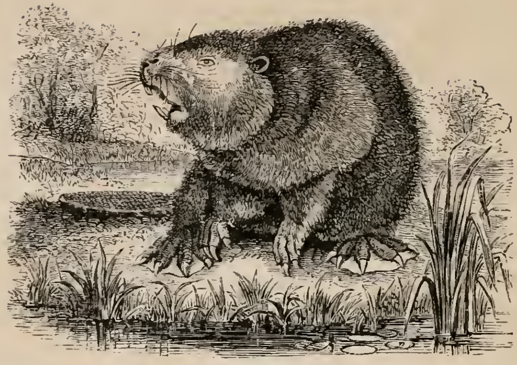


Pouched Gopher, *Geomys bursarius*, Richardson.

As already indicated the Beavers or Castoridæ are the largest of all the living Rodents excepting only the Capybara; and in their habits they are among the most interesting of all the Mammalia. They have a broad flat tail, five toes to each foot, the hind feet webbed, and the second hind toe has a double claw. Their incisor teeth are very sharp and strong, enabling them easily to gnaw down hard-wood trees one or two feet in diameter. They feed mainly upon the bark of the trees which they cut down, and upon roots and aquatic plants.

Beavers prefer running water, in order that the wood which they cut may be carried to the spot where it is to be used. They keep the water at a given height by dams, which they build of trunks and branches mixed with stones and mud; and they build houses for winter with the same materials. Each house consists of two stories. The upper story is above water and dry, for the shelter of the animals

FIG. 142.



American Beaver, *Castor canadensis*, Kuhl.

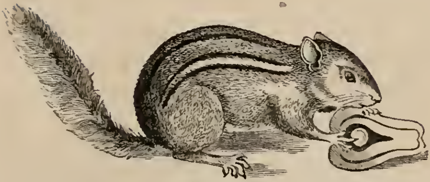
themselves; the lower is beneath the water, and contains their stores of bark and roots. The only opening to the hut is beneath the water. They have burrows in the banks, whither they retire when their houses are attacked. The general color of the beaver is a uniform reddish-brown, and the fur is of excellent quality. Our only living species (Fig. 142), is about two feet in length; a fossil species is more than twice as large.

The true Squirrels (*Sciurus*), the Flying Squirrels (*Pteromys*), the Striped Squirrels (*Tamias*), the Gophers and Spermophiles (*Spermophilus*), and the Prairie Dogs (*Cynomys*), are rodents which are included in the Squirrel family or Sciuridæ. In this family are also included the Marmots and Woodchucks (*Arctomys*).

The typical Squirrels (*Sciurus*), are the most graceful and beautiful of all the Rodents. They have compressed incisors, rather long ears, divided lip, and they are destitute of cheek pouches. The true Squirrels and Flying Squirrels live upon trees; the others in the ground.

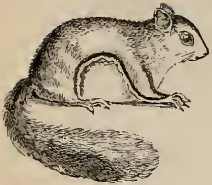
The Porcupines or Hystricidæ are conspicuous among

Fig. 143.



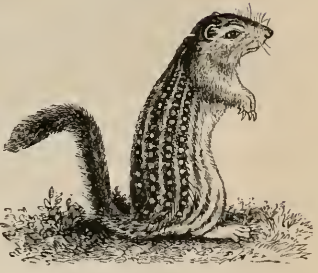
Striped Squirrel, *Tamias striatus*, Linnæus.

Fig. 144.



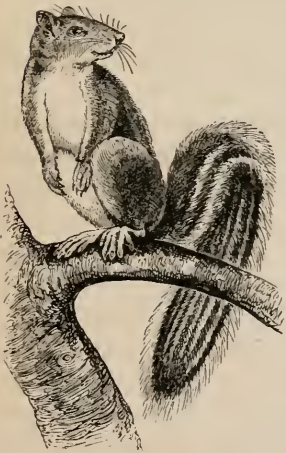
Flying Squirrel, *Pteromys volucella*, Desmorest.

Fig. 145.



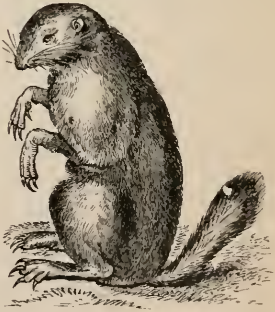
Leopard Spermophile, *Spermophilus tridecem-lineatus*, Audubon and Bachman.

Fig. 146.



Gray Squirrel, Southern var., *Sciurus carolinensis*, Gmelin.

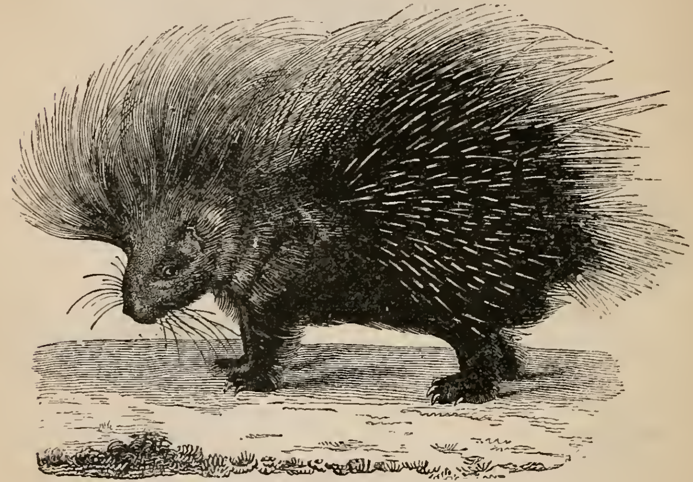
Fig. 147,



Prairie Dog, *Cynomys ludovicianus*, Baird.

all the Rodents on account of their spines, which serve them for a defensive armor. These spines lie flat upon the body when the animal is at rest, but are raised when the animal is excited. Our species have spines only a few inches in length, but a species (Fig. 148) of Southern Europe has very long spines, some of which attain a foot in length. Porcupines have a total length of about two and a half feet.

FIG. 148.



Crested Porcupine, *Hystrix cristata*, Linnæus.

All of the families of Rodents thus far noticed—together with the Agoutis or Dasyproctidæ, the Capybaras or Hydrochœridæ, and the Chinchillas or Chinchillidæ, all of South America—have only two incisors in the upper jaw and two in the lower.

But the little hare-like animals called Pikas or Lagomyidæ of the northern regions, and the Rabbits and Hares or Leporidæ of all parts of the world, differ from all other rodents by having each upper incisor with a smaller incisor behind it; that is, the formula for their incisors stands thus: $\frac{4}{2}$. And all the incisors are less deeply implanted in the jaws than in other rodents, and are white; and the molars are rootless. Rabbits and Hares have the feet clothed with hair beneath, and the inner surface of the cheeks lined with hairs. The tail is short and bushy; or it is only rudimentary. They feed upon bark, tender twigs, and leaves. Some live in burrows, but most have merely a *form*, or nest on the ground.

SUB-SECTION XIII.

THE ORDER OF EDENTATA OR EDENTATES.

This Order is sometimes called Bruta. Its members are deficient in teeth, as compared with other mammalia, all of them being destitute of incisors, and some kinds being wholly destitute of teeth; and the teeth when present are without enamel, and are never displaced by a second series. Ant-eaters, Sloths, and Armadillos are among the representatives of the Edentates. They all have long and strong claws.

This order has but comparatively few living representatives.

Some kinds, as the Ant-eaters or Myrmecophagidæ of the warm parts of South America, have a long muzzle, a toothless mouth, and filiform tongue capable of great extension; and they use this tongue, which is covered with a viscid saliva, in securing ants for food. The Giant Ant-eater of South America is four feet long, and it is said that its tongue can be elongated more than two feet!

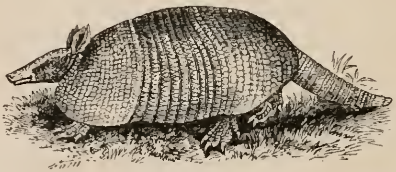
The Pangolins or Scaly Anteaters or Manidæ of the Eastern hemisphere, are edentates which are covered with plates or scales arranged like tiles on a roof.

The edentates known as Sloths or Bradypodidæ of South America are formed for living upon trees. They are of the size of the domestic cat or larger, and their forward limbs are very long, their mammæ pectoral, tail wanting or very short, and their hair long and coarse. With their long arms and long claws, they cling firmly around the branches of trees, and they almost always keep on the under side of the branch. In this position they move and repose in perfect security. On the ground they move awkwardly and with difficulty.

Sloth-like edentates, as the Megatherium, Mylodon, etc., have been found fossil, and of the most enormous dimensions, in the superficial deposits of South America. The skeleton of the Megatherium is eighteen feet long, and the thigh bone is about three times as thick as that of an Elephant! This animal was a huge ground Sloth. These and the living Sloths belong to the sub-order of TARDIGRADA.

None of the Edentates are more remarkable than the Armadillos or Dasypodidæ which are at once distinguished from all other mammals by their bony armor, or ossified exo-skeleton, as it is called. This armor is not a

FIG. 149.



Nine-banded Armadillo, *Dasypus novem-cinctus*, Linnæus.

consolidated framework, but is composed of several parts, so arranged as to allow freedom in the bending of the body. One large shield covers the head, another the shoulders, and another the rump, and between the two last there are several parallel movable bands of the same material. The tail in some cases is covered with successive rings, and in others, like the legs, with mere horny tubercles. All this armor is attached to the skin of the body; and it is made up of numerous many-sided plates placed together as inlaid work.

The Armadillos have a pointed muzzle, slightly extensible tongue, and powerful claws. They inhabit the warm and hot parts of America, dig burrows, and live upon vegetables, insects, and worms. They vary from about a foot and a half in length, besides the tail, as in the Nine-banded Armadillo of Texas and southward, to the Giant Armadillo of South America, which attains a length of three feet, besides tail.

The Glyptodon, a fossil Armadillo of South America, is compared to a huge cask in size, and has a total length of nine feet!

An armadillo-like animal (*Chlamydophorus truncatus*) found in Chili, differs from the true Armadillos in having only a series of transverse plates along the back, and these attached to the body only along the spine. This curious little edentate is only about six inches long. This animal and the Armadillos belong to the sub-order LORICATA.

SUB-SECTION XIV.

THE ORDER OF MARSUPIALIA OR MARSUPIALS.

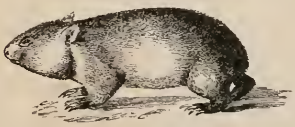
The Marsupials differ so widely from the true mammalia that they not merely constitute a distinct order, but they also, as we have seen on page 67, constitute a distinct sub-class of the Mammalia. They are separated from the true Mammalia by their peculiar structure, which is connected with the production and nourishing of their young.

Their young are brought forth in an exceedingly immature state of development; and in most cases, are received into a pouch or sack which is situated on the abdomen of the mother, where they are nourished by milk till they have acquired a degree of development corresponding to that in which other mammals are born. Even after they are able to walk the young resort to the pouch of the mother for safety in time of danger. The name of this group comes from the Latin *marsupium*, a pouch.

With the exception of one family, the Opossums, found in America, the Marsupials are confined to Australia and the adjacent islands. And it may be added here that it is a remarkable fact that nearly all the mammalia of Australia belong to this curious group of animals.

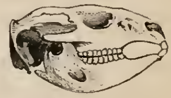
The Wombats or Phascolomyidæ are marsupials with a heavy body, as large as that of a medium-sized dog or larger, but with very short legs. In their teeth they are closely allied to the Rodents, as they have only two incisors in each jaw, and each of their molars has transverse ridges.

FIG. 150.



Wombat, *Phascolomys ursinus*, Cuvier.

FIG. 151.

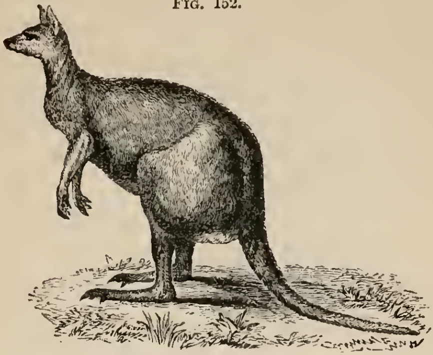


Skull of Wombat.

The Kangaroos or Macropodidæ are marsupials which have a remarkable development of their hinder parts.

The hind legs and the tail are long and powerful; the fore legs very short and weak, and little used in progression, which is accomplished mainly by leaping, for which their whole structure is most admirably fitted. They sit mainly upright upon their haunches, supported in part by the tail. Forty species are known, varying from the size of a hare to the size of the domestic sheep.

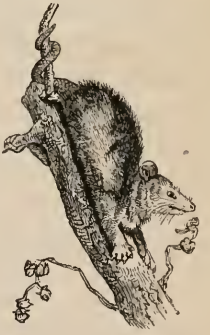
FIG. 152.



Kangaroo, *Macropus major*, Shaw.

All the marsupials of America belong to the Opossum family or Didelphidæ. Opossums are mostly small animals, the largest scarcely exceeding the common cat, and the smallest but little larger than a mouse. Their food consists of birds, birds' eggs, insects, and other small animals. The tail is long, prehensile, and nearly naked. The Common Opossum of the United States is about twenty inches long to the tail, which is about fifteen inches. The hair is whitish with brown tips,

FIG. 153.



Common Opossum, *Didelphys virginiana*, Shaw.

imparting a dusky shade. It often lies motionless for hours in the warm sunshine. When captured, slightly wounded, it has the habit of feigning itself dead. The young, which at birth weigh only three or four grains, are placed in the pouch, where they remain growing very rapidly till four or five weeks old, when they begin to venture forth, but for a long time keep close to the mother, often clinging to her by their tails.

SUB-SECTION XV.

THE ORDER OF MONOTREMATA OR DUCKBILLS.

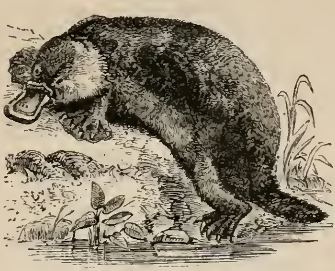
As stated in regard to the Marsupials, so it may be stated in regard to this order, that its members differ so widely from the typical mammals that they are not only regarded as a distinct order, but also as representatives of a distinct sub-class, as seen on page 67.

Monotremes are few in species, and belong to Australia and adjacent regions, and in some important respects their structure is much like that of Birds. Indeed, even their external structure at once suggests some likeness to that class of the animal kingdom. And like the Birds the Monotremes have only one passage for voiding the waste of the body. They are small animals, less than two feet in length, and are destitute of true teeth. The name Monotremata is derived from *monos*, one, *trema*, a pore.

They appear under two well-marked forms, although there are only a very few species. The Spiny Anteater (*Echidna*) is the representative of one form, which is covered with spines and has a long slender muzzle and an extensible tongue. It belongs to the family of Tachyglossidæ.

The Duckbill (*Platypus*) is another form of monotreme, which is covered with brown fur, and has a long flat muzzle very similar in its appearance to that of a duck, and which has webbed feet and a flat tail. This animal lives in ponds and quiet streams, and digs burrows in the banks. It represents the family of Ornithorhynchidæ.

FIG. 154.



Duckbill, *Platypus paradoxus.*

PRINCIPAL TOPICS CONSIDERED IN CHAPTER II., SECTION II.

SUB-SECTION I.

The Mammalia defined.—Their form and size.—Their digestive system.—Absorbent system.—Circulatory system.—Respiratory system.—Skeleton in general.—Skull.—Teeth.—Dental formula.—Muscular system.—Reproductive system.—Nervous system.—Special senses.—Classification of the Mammalia.

SUB-SECTION II.

Man an order by himself.—Erect attitude.—Forward pair of limbs liberated from the function of mere locomotion.—Hand. —Brain.—Face.—Speech.—Mental and spiritual endowments.

SUB-SECTION III.

Quadrumana defined.—Their attitude not erect.—Hand inferior to that of Man.—Quadrumana inhabit warm regions.—Catarrhine monkeys.—Platyrhine monkeys.—Strepsorhine quadrumana or Lemuroidea.

SUB-SECTION IV.

Carnivora defined.—Cats.—Hyenas.—Civets.—Dogs, etc.—Fishers, Martens, Sables, Weasels, Minks, Gluttons, Skunks, Badgers, Otters, etc.—Bears, Raccoons, etc.—Seals, and the Walrus.

SUB-SECTION V.

Ungulata defined.——Their teeth.——Artiodactyls.——Ruminantia.——Camels and Llamas.——Giraffe.——Oxen, Antelopes, Goats, Sheep, etc.——Pronghorn.——Deer.——Hippopotamus.——Hogs, etc.——Perissodactyls.——Horse, etc.——Rhinoceroses.——Tapirs.

SUB-SECTION VI.

Hyracoidea.——Size and appearance.——Their feet and teeth.

SUB-SECTION VII.

Proboscidea.——The Elephant.——Size.——Proboscis.——Teeth.——Mastodon.

SUB-SECTION VIII.

Sirenia.——Their appearance, structure, and habits.——Kinds of Sirenians.

SUB-SECTION IX.

Cetacea.——Their appearance and structure.——Zeuglodonts.——Denticetes.——Sperm Whales.——Mysticetes.——Right Whales.

SUB-SECTION X.

Chiroptera.——Their structure and habits.——Insectivorous Bats.——Frugivorous Bats.

SUB-SECTION XI.

Insectivora.——Their structure and habits.——Galeopethecus.——Shrews.——Moles.——Hedgehogs.——Tenrecs.

SUB-SECTION XII.

Rodentia.——Their structure.——Teeth.——Size.——Jerboas, Rats, etc.——Pouched Gophers, etc.——Beavers, Squirrels, Porcupines, Hares, etc.

SUB-SECTION XIII.

Edentata.——Their structure.——Ant-eaters.——Sloths.——Megatherium, etc.——Armadillos.

SUB-SECTION XIV.

Marsupialia.——Belong in Australia and America.——Their structure.——Wombats.——Kangaroos.——Opossums.

SUB-SECTION XV.

Monotremata.——Belong to Australia.——Their structure.——Spiny Anteater.——Duckbill.

SECTION III.

THE CLASS OF AVES OR BIRDS.

SUB-SECTION I.

BIRDS CONSIDERED AS A CLASS.

ALL of the egg-laying or oviparous vertebrates which are clothed with feathers and organized for flight belong to the Class of Birds—one of the most interesting and one of the best defined groups in the Animal Kingdom.

The feathers of Birds do not grow from the entire surface of the body, but are symmetrically and systematically arranged in rows and patches, with bare intervening spaces; they overlap one another, however, so as in most cases to cover the whole body.

The wings are furnished throughout the whole length with a range of quills, thus presenting a great surface to the air.

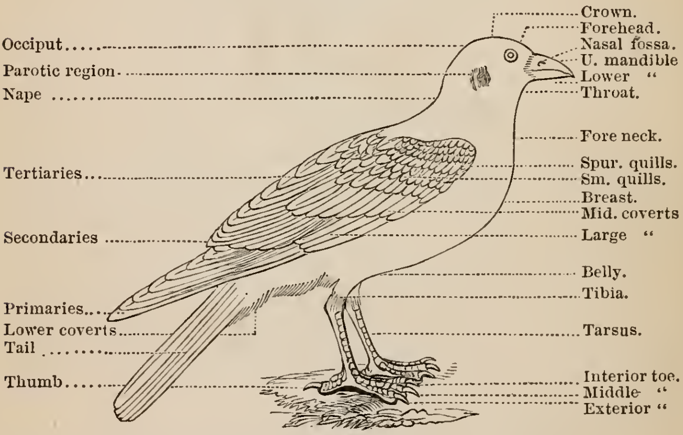
Birds are furnished with a bill, and their neck is so long and flexible that with the bill they can touch every part of the body. They have only two feet, the forward locomotive members being modified for wings.

In some species the wings are not sufficiently developed to serve the purpose of true flight; yet even in these cases they greatly assist in locomotion by beating the air, as exemplified in the Ostriches, or by striking the water as in the case of the Penguin (Fig. 210).

The quills attached to the hand are called *primaries,* and are the largest and firmest; those attached to the forearm are called *secondaries;* and those attached to the humerus, *tertiaries.* Ranges of shorter feathers cover the bases of the quills above and below, and are called *coverts.* The feathers that grow from the shoulders are called *scapulars;* those from the thumb, *spurious quills.*

The tail has a range of long quills, with upper and lower coverts, which serve both for ornament and to aid in supporting and guiding the animal in the air.

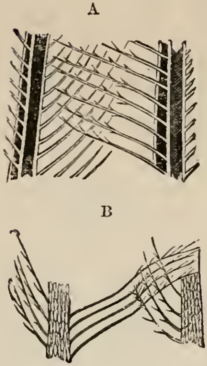
FIG. 155.


Crown.
Forehead.
Nasal fossa.
U. mandible
Lower "
Throat.
Occiput
Parotic region
Nape
Fore neck.
Spur. quills.
Sm. quills.
Tertiaries
Breast.
Mid. coverts
Secondaries
Large "
Belly.
Tibia.
Primaries
Lower coverts
Tail
Tarsus.
Thumb
Interior toe.
Middle "
Exterior "

Showing the names of some of the principal parts of a Bird.

Both the quills and the feathers consist of two parts, the *shaft* and the *vane;* the former is the axis, and the latter the expanded part. The vane consists of plates or laminæ, which are connected by minute barbs or hooks along their edges, and are thus rendered firm to resist the air. There are, however, on every bird, downy feathers, or such as do not have the laminæ united.

FIG. 156.



Magnified portions of Feathers, showing the structure of the laminæ.

A, Bird of Paradise ; B, Goose.

The plumage of Birds is rendered water-proof by the oil with which they dress their feathers, and which is furnished by a gland situated on the tail.

Feathers are modifications of the epidermis, and they are the most complicated of all the various forms under which the epidermis appears.

Birds moult their feathers twice a year. In some, the winter plumage differs in its colors from that of the summer. In most cases the colors of the male are more brilliant than those of the female; and when this is the case, the young of both sexes resemble the adult female. When the adult male and female are of the same color, their young have colors peculiar to themselves.

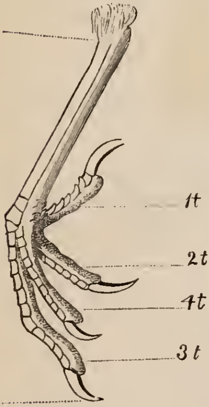
It has been stated on a previous page that Birds are covered with feathers. But it may be added here that the legs of most birds are more or less naked or destitute of feathers. All the so-called naked portions of the legs, however, are covered with a more or less hard integument, varying from somewhat skinny, as in the Water Birds, to horny, as in the Land Birds. This covering is variously modified, divided, and subdivided, forming *scales* or *scutella*, *plates* or *reticulations*, and *tubercles* or *granulations.* In some cases, however, as in the Thrushes, etc., the tarsus shows few or no divisions except near the toes; and such a tarsus is said to be "booted."

Scutella are arranged in more or less regular series or up and down rows, and in most cases they are imbricated, or arranged like tiles on a roof; as in the Mocking-bird and Cat-bird (Fig. 158).

Plates or *reticulations* are not in regular series, and they are not imbricated, but meet edge to edge; as in the Plover (Fig. 159).

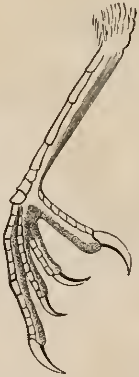
Granulations are elevated plates; as in the Osprey.

FIG. 157.*



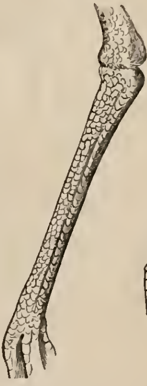
Booted tarsus—Robin.

FIG. 158.



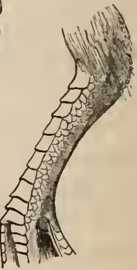
Scutellate tarsus—Cat-bird.

FIG. 159.



Reticulate tarsus—Plover.

FIG. 160.



Scutellate tarsus—Pigeon.

1t 2t 3t and 4t indicate 1st, 2d, 3d, and 4th toes.

The horny covering upon the mandibles performs the functions of teeth. The stomach may be regarded as composed of three parts—the *crop*, which is an enlargement of the œsophagus; a *membranous stomach*, in whose walls are numerous glands which furnish juices to moisten the food; and the *gizzard*, where the food is finally digested. The nutrient products of digestion are taken from the

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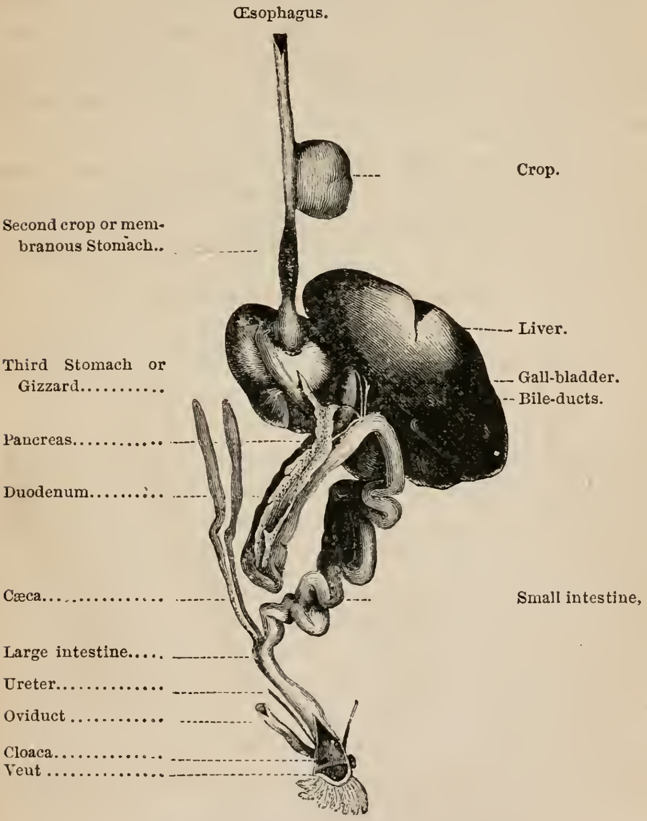
* Figures 157–160, and 238, are from Coues' "Key to North American Birds."

Fig. 161.


Œsophagus.
Crop.
Second crop or membranous Stomach..
Liver.
Third Stomach or Gizzard..........
Gall-bladder.
Bile-ducts.
Pancreas..........
Duodenum........
Cæca..............
Small intestine,
Large intestine.....
Ureter.............
Oviduct ....
Cloaca.............
Vent ....

Digestive apparatus of a Bird—Common Fowl.

small intestine by lymphatic vessels which end in two thoracic ducts that open into the jugular veins on each side of the base of the neck.

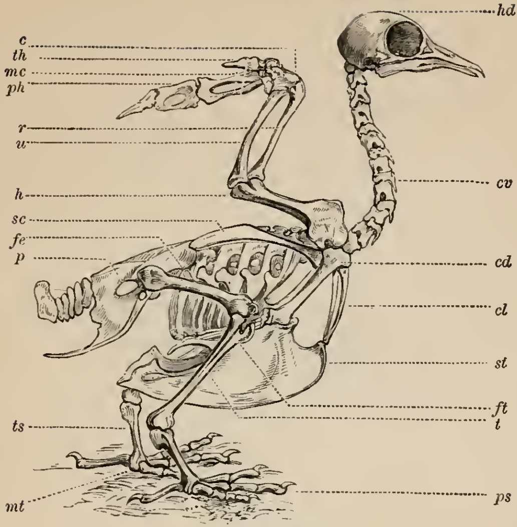
The circulatory system of Birds is essentially the same as that of Mammals. The blood is hotter than that of any other vertebrates, and is rich in corpuscles, and the corpuscles are elliptic in shape, and nucleated (Figs. 36 and 37, page 36.) Birds have only a single aortic arch, namely, the right.

The respiratory system of Birds is extensive, and varies considerably from that of the Mammals. The cavity of the chest is not limited by a diaphragm, and the lungs are not suspended as free sacs in the cavity of the trunk, but are attached in the form of flattened spongy masses to the posterior side of the thorax, reaching even to the pelvis. Air-sacs on the surface of the lungs and in various parts of the body, and even the bones themselves, which are hollow, are in communication with the lungs, and thus greatly enlarge the means of respiration, as well as diminish the specific gravity of the animal, thus the better adapting it for locomotion through the air. So completely are the bones in communication with the lungs, that it is said, that if the windpipe be tied, and the humerus be cut off, and the end left exposed, the bird can inspire and expire through the opening in the end of the bone!

The motatory apparatus of Birds, as in Mammals, consists of a skeleton, muscles, tendons, and ligaments.

As regards the skull of Birds, it is articulated with the first vertebra of the neck by only one occipital condyle, as in Reptiles; and as in the latter class, each ramus or branch of the lower jaw is composed of several pieces, and is connected with the skull by what is called the os quadratum or quadrate bone.

FIG. 162.



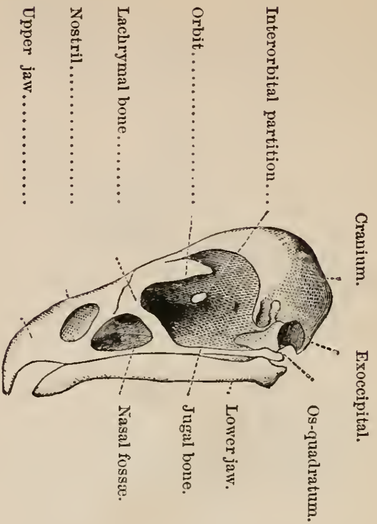
Skeleton of a Bird.

hd, head; *cv*, cervical vertebræ; *p*, pelvis; *sc*, scapula; *cl*, clavicle; *cd*, corocoid bone, formerly regarded as a second clavicle; *st*, sternum; *h*, humerus; *u*, ulna; *r*, radius; *c*, carpus; *mc*, metacarpus; *ph* and *th*, phalanges, *th* being the thumb; *fe*, femur; *ft*, fibula and tibia, more or less united; *t*, tibia, or where the fibula is no longer seen, or only faintly indicated; *ts*, tarsus; *mt*, metatarsus more or less consolidated with the tarsus; *ps*, phalanges or toes.

The upper jaw or mandible of Birds is so articulated with the cranium that it can move independently of the lower jaw—a peculiarity which is not found in the Mammalia.

The trunk, serving as a point of support for the extended locomotive members, has little flexibility, the vertebræ of this portion being more or less firmly joined together. The pelvis is much lengthened, furnishing points of attachment for the muscles of the thighs; and the sternum is of great extent, to bear the extensive muscles for moving the wings in flight. The ribs are

FIG. 163.


Upper jaw
Nostril
Lachrymal bone
Orbit
Interorbital partition
Cranium.
Exoccipital.
Os-quadratum.
Lower jaw.
Jugal bone.
Nasal fossæ.

Skull of a Bird—Eagle.

ossified throughout their whole length, in order to give greater strength to the trunk; and a small bone is attached obliquely across each rib, which also contributes to the same result.

Regarding the wrist as part of the hand, each wing is made up of three sections,—the arm, forearm, and hand,—thus corresponding to the anterior extremities of man and other mammals.

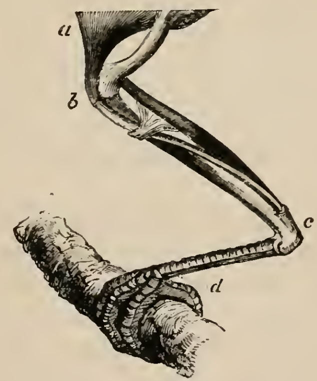
The hind locomotive members of Birds are each composed of a femur, a tibia and fibula, the last two more or less united; a tarsus and metatarsus, the latter more or less merged in the former; and generally of three toes before and a thumb behind, the latter, however, sometimes wanting.

The number of joints in the thumb of birds is two, in the next toe three, in the next four, and in the outer one five. The bones of birds are hollow, as already stated; hence very light in comparison with their size and strength. They are more laminated, and less fibrous, than the bones of any other vertebrates.

The bones of the Penguin—a bird which does not fly—are solid and heavy; and those of the Apteryx—a wingless bird of New Zealand—are nearly solid, having only a small medullary cavity in the femur.*

The muscles of birds are relatively large and powerful. And here it may be stated as an interesting fact, that

FIG. 164.



Position of the leg of a Bird in perching.

The weight of the bird, by bending the joint *b* and the joint *c*, puts the muscle *a*, *b*, *c*, *d* upon the stretch, and thus flexes the toes.

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* The bones of all birds, and of all other vertebrates, are at one stage of their formation essentially solid; that is, they are not hollow, and they have no cavities of any sort. The hollowness and the cavities are produced by the removal—by absorption—of bony tissue previously formed; and thus is the bone adapted for the function it is to perform. "The thinnest-walled and widest air-bone of the bird of flight was first solid, next a marrow-bone, and finally became the case of an air-cell."—OWEN.

there is a series of muscles reaching from the pelvis to the toes, and so arranged that the mere weight of the bird flexes the toes, and thus enables it to sleep in perfect security, even though perched on one foot.

The nervous system of Birds is well developed, and the cerebral hemispheres are superior in size to the other parts; but the cerebrum has no convolutions; and there is no corpus callosum; and the cerebellum is transversely grooved. The optic lobes, which in Mammals are small and concealed by the brain, are comparatively large in Birds, and plainly seen without dissection.

Birds have the most piercing and distinct power of sight, and they seem to distinguish objects near or remote with equal facility. The eye is protected by lids, and besides the horizontal eyelids there is one placed at the inner angle which can instantly be drawn over the eye like a curtain; it is called the nictitating membrane, and performs a most important office in protecting this delicate organ.

Birds, as a class, have no external ear; but they have an external tube, a tympanic cavity or middle ear, and an internal ear. Owls, however, have an external conch.

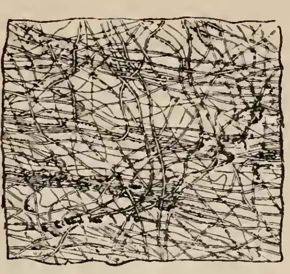
The organ of smell is situated in the base of the bill, and the sense of smell is thought to be little developed.

The tongue, in most species, has but little muscular substance, and the taste is probably not very delicate.

The sense of touch is also feeble, and the nature of their wings and feet is accordingly unfavorable for the exercise of this faculty.

Birds lay eggs, and sit upon them to hatch them. The egg in the ovary consists merely of the part we call yolk; it imbibes the external fluid called the white in the upper part of the oviduct, and becomes covered with a shell at the bottom of the same canal. The eggs are hatched by being kept at a temperature of 104° Fahr. By a beautiful arrangement the yolk and its germ are always kept in the right position, no matter which side up the egg may be.

FIG. 165.



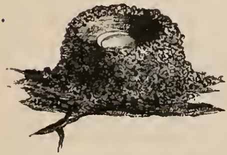
Fibrous membrane from an Egg-shell, Magnified.

The young bird has a horny point at the extremity of the bill, with which it breaks the shell; this falls off a few days after the bird is hatched.

Professor J. W. P. Jenks has recently discovered that the shell is first pierced by the forward and backward motion of the under mandible, and the aperture thus made is then enlarged and the shell broken by the upper mandible and its horny point.

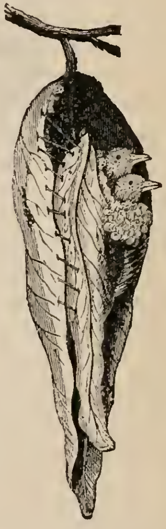
Most birds build nests in which to lay their eggs; and it is an interesting fact that all individuals of a species build essentially alike, and, in a given locality, of the same kinds of materials. Their skill and industry in nest-building are truly wonderful. Some kinds build with sticks; others with dried grasses and hair; others with mud and dried grasses; others mainly with the woolly covering of the stalks of ferns; others, as some kinds of Humming-birds, largely with lichens; and so on, through a long list of materials that might be enumerated, but which it is not necessary to enumerate here. Some kinds, like the Oriole, weave a nest of fibrous materials—as those from the stalks of the silkweeds—suspending the structure from the outermost twigs of the elm or other trees, where it swings secure from nearly all enemies. And others, as the Tailor-bird of India, convert the cotton of the cotton-tree into threads, and with these form a nest by sewing together living leaves (Fig. 167).

Fig. 166.



Humming-Bird's Nest.

Fig. 167.



Nest of Tailor-Bird, *Sylvia sutoria*, of the East Indies.

Their ability to anticipate atmospheric changes is truly wonderful, and caused the ancients to attribute to birds the power of divination.

The longevity of birds is regarded as about ten times as great as the time which they require to come to full growth. Domestic fowls live to the age of twenty years; parrots, thirty years; geese, fifty; while swans, ravens, and eagles are said to live a century.

The Class of Birds, like most other classes in the Animal Kingdom, has been variously divided.* This is owing partly to real progress in science, and partly to the fact that different naturalists attach different degrees of importance and different meanings to the various parts of the structure of these animals. Huxley and some others recognize only three Orders of Birds :

1. CARINATÆ, from the Latin *carina,* a keel ; the birds of this order have the sternum raised into a ridge or keel. Here belong all the ordinary birds, as Falcons, Woodpeckers, Sparrows, Crows, Pigeons, Grouse, Herons, Ducks, etc.
2. RATITÆ, from the Latin *ratis* a raft ; the birds of this order have the sternum flat or keel-less, that is raft-like ; as the Ostriches, Apteryx, etc.
3. SAURURÆ, so named from the Greek *saura,* a lizard, and *oura* a tail ; the vertebræ of the tail are numerous, thus making it long like that of a lizard ; as the Archæopteryx (fossil).†

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* The Smithsonian Institution has adopted, provisionally, the following arrangement of the divisions and subdivisions of the Class of Birds :

SUB-CLASS I.—INSESSORES.

ORDER I.—PASSERES, including *Oscines*, as the Thrushes, Warblers, Sparrows, etc., and *Clamatores*, as the Tyrant Flycatcher, etc.

ORDER II.—STRISORES, as the Kingfishers, Goatsuckers, Humming-birds, etc.

ORDER III.—ZYGODACTYLI, as the Cuckoos, Woodpeckers, Parrots, etc.

ORDER IV.—ACCIPITRES, as the Falcons, Owls, Vultures, etc.

ORDER V.—PULLASTRÆ, as the Pigeons, Curassows, etc.

SUB-CLASS II.—CURSORES.

ORDER VI.—GALLINÆ, as the Turkeys, Grouse, Pheasants, etc.

ORDER VII.—BREVIPENNES, as the Ostriches.

ORDER VIII.—GRALLÆ, as the Plovers, Snipes, Herons, etc.

SUB-CLASS III.—NATATORES.

ORDER IX.—LAMELLIROSTRES, as the Swans, Geese, Ducks, etc.

ORDER X.—STEGANOPODES, as the Pelicans, Gannets, Frigate-birds, Cormorants, Snake-birds, and Tropic-birds.

ORDER XI.—LONGIPENNES, as the Gulls, Terns, Albatrosses, Petrels, etc.

ORDER XII.—PYGOPODES, as Divers, Grebes, Auks, and Penguins.

† In fossil forms of birds there are perhaps two distinct orders :

1. Saururæ, represented by *Archæopteryx.*
2. Ichthyornithides, represented by *Ichthyornis* and *Aptornis.*

The following classification is adopted in "*A History of North American Birds*," by S. F. Baird, T. M. Brewer, and R. Ridgeway:[*]

A. PASSERES (including Oscines and Clamatores), as Swallows, Warblers, Sparrows, Thrushes, Flycatchers, etc.

B. PICARIÆ, as Humming-birds, Cuckoos, Woodpeckers, Goat-suckers, etc.

C. PSITTACI, as Parrots, etc.

D. RAPTORES, as Owls, Falcons, Vultures, etc.

E. COLUMBÆ, as Doves.

F. GALLINÆ, as Turkeys, Grouse, Quail, etc.

G. LIMICOLÆ, as Avosets, Turnstones, Plovers, Snipe, etc.

H. HERODIONES, as Herons and Ibises.

I. ALECTORIDES, as Rails, Coots, Gallinules, etc.

J. LAMELLIROSTRES, as Flamingoes, Ducks, and Geese.

K. STEGANOPODES, as Gannets, Pelicans, Cormorants, Snake-birds, etc.

L. LONGIPENNES, as Gulls and Petrels.

M. PYGOPODES, as Divers, Grebes, and Auks.

N. SPHENICI, as Penguins only.

Having presented some of the most recent and important classifications of the Birds, we may now present the old division of the Class of Birds into seven groups or orders—omitting fossil species,—and introduce the more modern names in the proper places, so as to show the relations of the most recent classification to the old. The seven groups of living species of birds, which have long been treated as orders, are—

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[*] It may be remarked here that in the introduction of this work—written by Dr. Gill—the authors feel compelled "to question the existence of any groups of ordinal value among recent birds."

1. RAPTORES or Birds of Prey, which are generally of a rather stout form and large size; and have strong, hooked bills, sharp claws, great extent of wing and powerful muscles; and whose females are generally larger than the males; as Falcons, Owls, and Vultures.
2. SCANSORES or Climbing Birds (including PICARIÆ, as Toucans, Trogans, Cuckoos, Woodpeckers; and PSITTACI, as Parrots), which in general have their toes in pairs, two in front and two behind.
3. INSESSORES or Perching Birds (including OSCINES, as Swallows, Warblers, Sparrows, Thrushes, etc.; and CLAMATORES, as Flycatchers, etc.). These birds differ much among themselves, but all have three toes before and one behind and their feet well adapted for perching. This group is often called PASSERES.
4. RASORES or Scratching Birds (including COLUMBÆ, the Doves, etc.; and GALLINÆ, Grouse, etc.), a group of stout-bodied birds, adapted mainly for living upon the ground.
5. CURSORES or Runners, which are of large size, with a very long neck and very long legs, and with only rudimentary wings; as the Ostriches.
6. GRALLATORES or Wading Birds (including LIMICOLÆ, as Plovers, Snipe, Woodcock, etc.; HERODIONES, as Herons, Ibises, etc.; and ALECTORIDES, as Cranes, Rails, etc.), which have the bill, neck and legs very long and slender, and a slender body.
7. NATATORES or Swimming Birds (including LAMELLIROSTRES, as Ducks, Geese, etc.; STEGANOPODES, as Gannets, Pelicans, Cormorants, etc.; LONGIPENNES, as Gulls and Petrels, etc.; PYGOPODES, as Loons, Grebes, Auks, etc.; and SPHENICI, as Penguins only).*

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* Bonaparte and some others divide the birds into two Sub-classes:

1. ALTRICES, or those whose young are hatched in a very feeble condition, and which have to be fed for a considerable time by the parent, as Falcons, Parrots, Thrushes, etc. The name is from the Latin *altrix*, nourishing.
2. PRÆCOCES, or those whose young are able to run, and pick up food, as soon as hatched, as Grouse, Snipe, Ducks, etc. The name is from the Latin *præcox*, early mature.

Having made the student acquainted with some of the principal classifications of Birds, so far as regards the higher groups, we now adopt, for our present purposes, the classification presented on the 150th page, introducing, after the Gallinæ, only the additional group of Brevipennes, and treating all the groups, provisionally, as orders.

It must be stated here, however, that it is not probable that all these groups will ever be established as genuine zoölogical orders.

With this explanation, we may write all the higher groups of Birds as follow:—

1. Passeres, as Thrushes, Sparrows, Flycatchers, etc.
2. Picariæ, as Humming-birds, Cuckoos, Woodpeckers, etc.
3. Psittaci, as Parrots, etc.
4. Raptores, as Falcons, Owls, Vultures, etc.
5. Columbæ, as Doves.
6. Gallinæ, as Turkeys, Grouse, Quail, etc.
7. Brevipennes, as Ostriches, etc.
8. Limicolæ, as Avosets, Turnstones, Plovers, Snipe, etc.
9. Herodiones, as Herons, Ibises, etc.
10. Alectorides, as Rails, Coots, Gallinules, etc.
11. Lamellirostres, as Flamingoes, Ducks, Geese, etc.
12. Steganopodes, as Gannets, Pelicans, Cormorants, etc.
13. Longipennes, as Gulls and Petrels.
14. Pygopodes, as Divers, Grebes, and Auks.
15. Sphenici, as Penguins only.

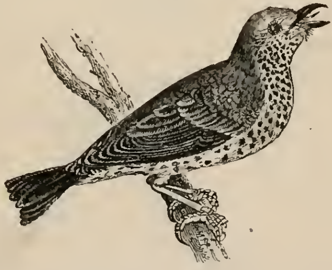
SUB-SECTION II.

THE ORDER OF PASSERES OR INSESSORES.

THE name Passeres comes from the Latin *passer*, a sparrow; and the name Insessores from the Latin *insideo*, to perch. The latter of these names is used by some ornithologists to designate a sub-class of birds, namely the Aërial Birds, including the old groups Raptores, Scansores, and Insessores. By others the name Insessores is used as essentially equivalent to Passeres; and in this latter sense we prefer to use it for our present purposes.

The Passeres, by the nature of their feet, are perfectly adapted for perching, the four toes being always present, the hind toe inserted on nearly the same level as the others, and perfectly opposite to the forward toes.

FIG. 168.



A Passerine or Insessorial Bird, Wood Thrush, *Turdus mustelinus*, Gmelin.

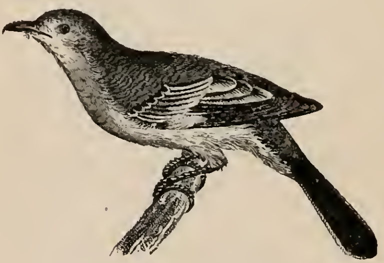
The Passeres have a horny bill; wings with nine or ten primaries, and more than six secondaries; and in most cases they have twelve tail feathers.

The Passeres are the most active of all birds; and they are regarded as the typical representatives of the Class, being the most complex of all in the details of their organization.

The Passeres include the Oscines, or Singing Birds, as the Thrushes, Blue-birds, Chickadees, Nuthatches, Creepers, Wrens, Warblers, Tanagers, Swallows, Waxwings, Vireos, Shrikes, Finches, Larks, Blackbirds, Starlings, Jays, Crows, and their numerous allies, all of which have a complex vocal apparatus, consisting of five pairs of muscles, although many of them do not really sing; and the Clamatores, as the Flycatchers, whose vocal organs are more simple or even rudimentary.

The Thrushes or Turdidæ have the bill notched near the tip, the wings with ten primaries, the tarsi booted, as in the robin, etc., or scutellate, as in the Cat-bird, etc., and the feet very deeply cleft. The Wood Thrush, the Hermit Thrush, the Robin, the Blue-bird, the Mockingbird, the Cat-bird, and the Brown Thrush are among our most interesting species. It should be added, however, that some writers class the Bluebirds under another family—the Saxicolidæ.

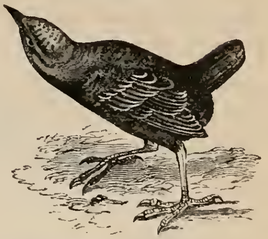
Fig. 169.



Mocking-bird, *Mimus polyglottus*, Boie.

Closely related to the Thrushes are the curious Water Ouzels or Cinclidæ, which frequent clear streams, into which they walk or dive and move about in search of water-insects and other small animals for food. The Water Ouzel (Fig. 170) of the Rocky Mountain regions is our only species.

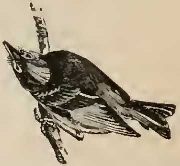
FIG. 170.



Water Ouzel, *Cinclus mexicana*, Baird.

Somewhat like the Thrushes, only much smaller, are the Sylvias or Sylviidæ, of which our Kinglets are examples. The Ruby-crowned Kinglet of North America is four and a half inches long, and is at once distinguished by the crown, which has a large concealed patch of scarlet feathers which are white at the base.

FIG. 171.



Ruby-crowned Kinglet, *Regulus calendula*, Licht.

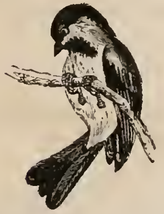
The Chickadees or Titmice or Paridæ (Fig. 172), are very small oscines, about five and a half to seven inches long, with ten primaries, and mostly of plain colors. They are very pretty little birds, and are seen at all seasons of the year, even in the severest weather of winter.

The Nuthatches or Sittidæ (Fig. 173) are small oscines, four to six inches long, with a slender, straight, but apparently slightly recurved bill, and with long wings which have ten primaries, the first of which is very short or spurious. They feed upon nuts and insects. They move up and down the tree-trunks and along the branches with the greatest facility, easily assuming every possible attitude.

The Creepers or Certhiadæ (Fig. 174), are small oscines, which have a decurved bill and rigid tail-feathers similar to those of a woodpecker. They are very active and move along the trunks and branches, searching in the cracks for insects, upon which they feed.

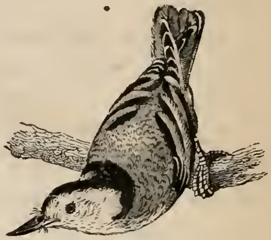
The Wrens or Troglodytidæ are a large group of very small, and exceedingly active, plain-colored birds, more or less related to the Creepers, Nuthatches, etc., but readily distinguished by their general form, which is well shown in Fig. 175. Audubon says that the song of the Winter Wren excels that of any other bird of its size with which he is acquainted.

FIG. 172.



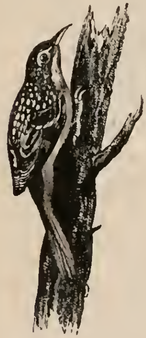
Titmouse or Chickadee,
Parus atricapillus, Linn.

FIG. 173.



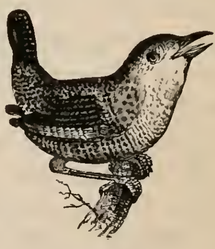
Nuthatch,
Sitta Carolinensis.

FIG 174.



Brown Creeper,
Certhia familiaris.

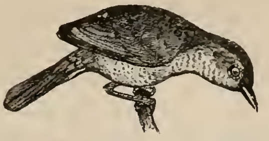
FIG. 175.



Winter Wren,
Troglodytes hyemalis, Vieillot.

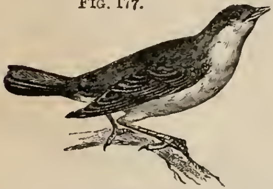
The Warblers or Sylvicolidæ (Figs. 176–178), are very small—generally less than six inches in length—but exceedingly beautiful and interesting birds. They have the bill usually half the length of the head, nine primaries, the tarsi distinctly scutellate anteriorly, the lateral toes nearly equal and shorter than the middle one, and the basal joint of the middle one free nearly to its base externally, and united for half the length interiorly. Many species of warblers are often found in the same locality, and may be seen a great part of the day gliding among the thick foliage, busily engaged in catching the minute insects which lurk beneath the leaves and in the buds and blossoms, and which, for the most part, escape the sight of other and larger birds. Some species of the warblers—as the Nightingale—are among the sweetest of the feathered songsters.

FIG. 176.



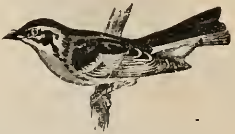
Maryland Yellow-throat Warbler—female, *Geothlypis trichas*, Cabanis.

FIG. 177.



Nightingale,
Philomela luscinia, Sw.

FIG. 178.



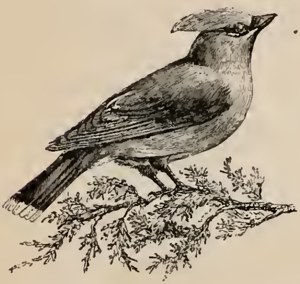
Blackburnian Warbler,
Dendroica Blackburniæ, Baird.

Closely related to the Warblers are the Tanagers or Tanagridæ, a very large group of oscines, noted for their brilliant plumage. Here belong the Scarlet Tanager, the males of which are wholly bright scarlet, except the wings and tail, which are black; and the Summer Redbird of the Southern States, a bird whose general color is light red.

The Swallows or Hirundinidæ, are oscines at once distinguished by their very short, depressed, and triangular bill, long wings, very short tarsi, and, generally, forked tail.

The Waxwings or Ampelidæ, are so named because the inner quills of their wings are furnished with horny appendages that resemble sealing-wax. They have a short and broad bill, both mandibles notched, and the upper one with a tooth behind the notch. Our most common species is the well-known Cedar Bird, which is seven and a quarter inches long.

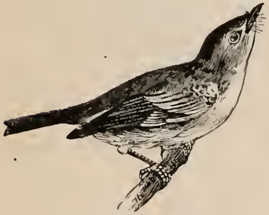
Fig. 179.



Cedar Bird,
Ampelis cedrorum, Baird.

The Vireos or Vireonidæ are oscines which have the bill stout, compressed, and distinctly notched, and hooked at the tip, and the wings with ten primaries, the first of which is short or apparently wanting. They are small, only five or six inches long, of a general olive color above, and white below; and they are among the most interesting songsters of our groves and forests. They live mostly among the tree-tops and in the thick foliage, where their clear and sweet notes may be heard throughout the day.

Fig. 180.



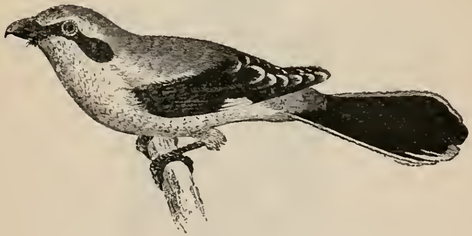
Warbling Vireo or Flycatcher,
Vireo gilvus, Bonaparte.

The Shrikes or Laniidæ are strikingly prominent among the Oscines, on account of their strong, abruptly-hooked, notched, and toothed bill, which seems to ally them to the Falcons. And in strict accordance with this structure of the bill, they are rapacious in their habits, preying more or less upon small birds and quadrupeds.

The Shrikes have a most singular habit of impaling their prey upon thorns and sharp twigs; but for what purpose they do this is not known.

The Great Northern Shrike, or Butcher-bird, of North America is about nine inches long, and its general color is light-bluish ash; a stripe on the side of the head, and the wings and tail are black.

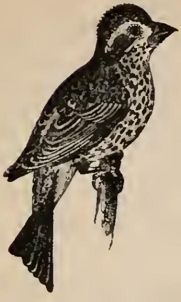
FIG. 181.



Great Northern Shrike, *Collurio borealis*, Baird.

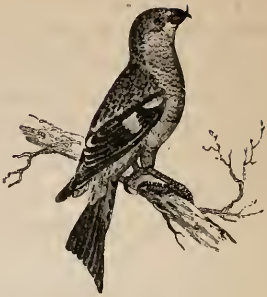
The Grosbeaks, Finches, Crossbills, Linnets, Goldfinches, Buntings, Sparrows, Chewinks, etc., and their allies are oscines which belong to the great family of Fringillidæ, the largest family of birds in North America. It may be stated in general terms, that the Fringillidæ have a short, stout, conical bill, nine primaries, tarsi which are scutellate in front and the sides with undivided plates, meeting and forming a sharp ridge behind. They are mostly small birds, and, with few exceptions, their colors are plain. Some, however—as the Rose-breasted Grosbeak—are among the most beautiful of birds.

FIG. 182.



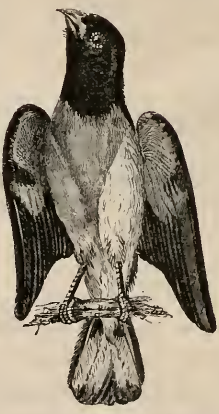
Purple Finch,
Carpodacus purpureus, Gray.

FIG. 183.



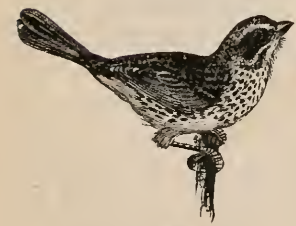
White-winged Crossbill,
Curvirostra leucoptera, Wilson.

FIG. 184.



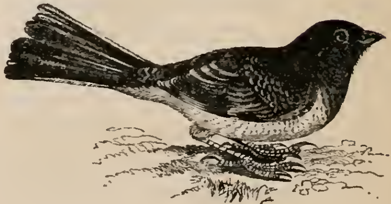
Rose-breasted Grosbeak, *Guiraca ludoviciana*, Swainson.

FIG. 185.



Song-Sparrow, *Melospiza melodia* Baird.

FIG. 186.

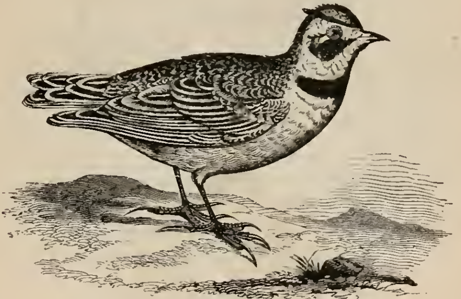


Chewink, *Pipilo erythrophthalmus*, Vieillot.

And nearly all are singers; some of them are among our sweetest songsters.

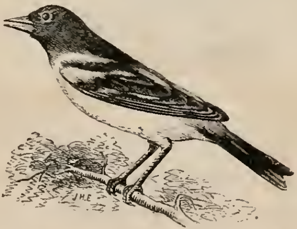
Of the Larks or Alaudidæ—the family to which the famous Skylark of Europe belongs—there is in the United States but a single species, namely, the Shore Lark, or "Horned" Lark, abundant on the plains and prairies. It is nearly eight inches long. The general color above is pinkish brown; a band across the crown and running back along the lateral tufts, and a patch below the eye and along the side of the head, and a pectoral crescent are black; the frontal band and under parts are white. It sings sweetly while on the wing, but its song is short.

FIG. 187.



Shore Lark, *Eremophila alpestris*, Boie.

FIG. 188.

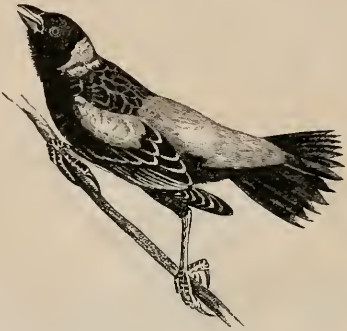


Baltimore Oriole, *Icterus Baltimore*, Daudin.

The Bobolinks, Cow-birds, Blackbirds, Meadow-Larks, Starlings, Orioles, Crow-blackbirds, Jackdaws, etc., are oscines which agree in having the body relatively rather long, and the bill rather long, and mostly very acute; and together they constitute the family of Icteridæ.

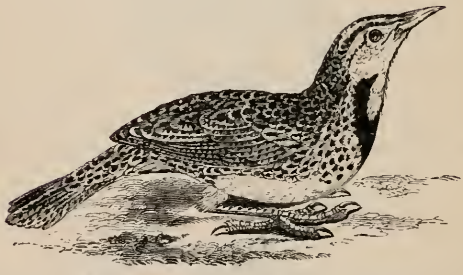
The well-known Bobolinks, or Reed-birds, or Rice-birds, (Fig. 189), are less than eight inches long and are among the most spirited of songsters. The Cow-birds are remarkable for their parasitic habits.

Fig. 189.



Bobolink, *Dolichonyx oryzivorus*, Swainson.

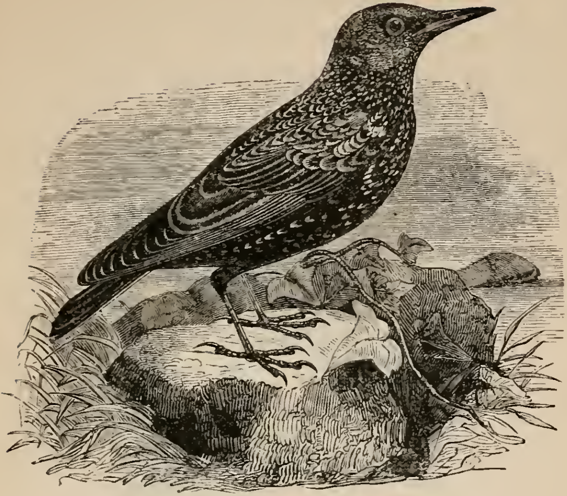
Fig. 190.



Meadow-Lark, *Sturnella magna*, Swainson.

Like the European Cuckoo, the Cow-bird makes no nest, but stealthily lays its eggs, only one in a nest, in the nests of other birds, espe-

Fig. 191.



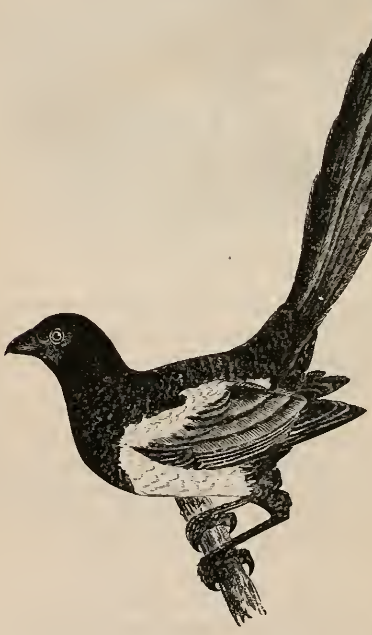
European Starling, *Sturnus vulgaris.*

cially in those of the Maryland Yellow-throat, several Flycatchers, the Blue-bird, Chipping Sparrow, and Golden-crowned Thrush. The egg is pale grayish-blue, sprinkled with umber-brown dots and short streaks; and it is a remarkable fact that it hatches before the eggs of the bird in whose nest it is laid. No sooner has the young Cowbird hatched, than the foster-parents fly off to obtain food for it, and hence their own eggs perish, and are at length thrown from the nest. The young bird is cared for with all tenderness, and fed even long after it has begun to fly about, and after it has become larger than the foster-parents themselves.

The Ravens, Crows, Rooks, Magpies, Jays, etc., are insessorial birds which are relatively of large size, and which are united into one family called the Corvidæ. They have a rather stout bill; the nostrils are covered with tufts of bristly feathers; they have ten primaries; twelve tail-feathers; and the tarsi have each a scutellum in front, separated from the rest of the tarsal covering by a groove.

The Ravens are the largest of the Corvidæ, being about two feet long, and readily distinguished from the Crows, not only by their larger size, but by the feathers of the throat, which are long, acute, and separated; while the feathers on the throat of the Crows are oval in shape and closely blended.

FIG. 192.

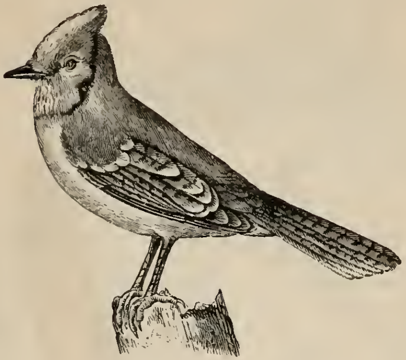


Magpie, *Pica hudsonica*, Bonap.

The Magpies (*Pica*) have the bill much curved, and the tail exceedingly long, making the total length of the bird about fifteen or twenty inches (Fig. 192).

The Jays usually have the head more or less crested, as seen in the well-known Blue Jay (Fig. 193), a bird which in beauty of plumage is scarcely surpassed, even if equaled, by any other bird in North America.

FIG. 193.

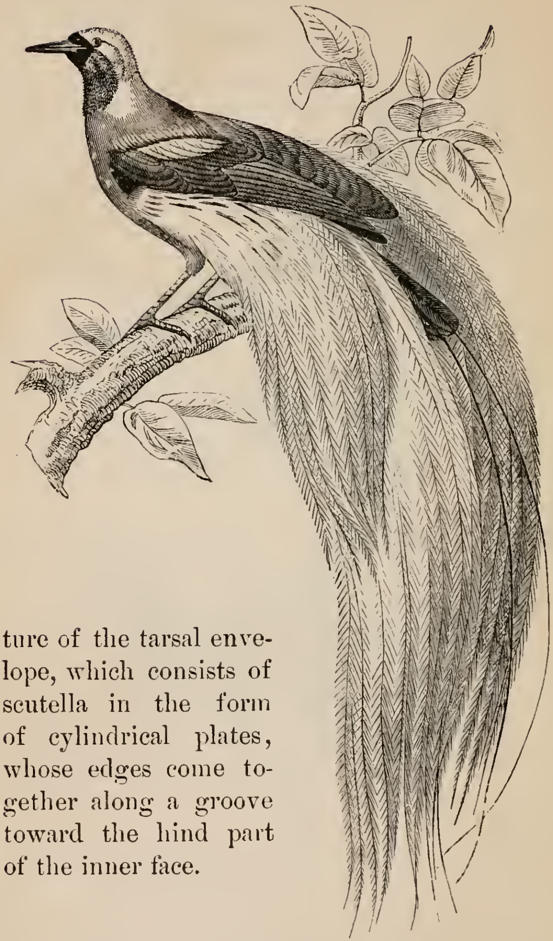


Blue Jay, *Cyanura cristata*, Swainson.

To the Passeres belong also the famous Birds of Paradise, the Paradiseidæ, whose plumage is wonderfully developed and exceedingly beautiful (Fig. 194.) One of the best known species has a body about the size of the common Robin; its general color maroon; head and neck yellow; the throat and around the bill emerald. On the sides of the body there is a splendid plume of delicate yellow feathers.

In the division of the Passeres called CLAMATORES the vocal muscles of the lower larynx are small, or merely rudimentary, as already stated; that is, these birds have no well-developed singing apparatus. The Clamatores are also distinguishable from the Oscines, by the struc-

Fig. 194.

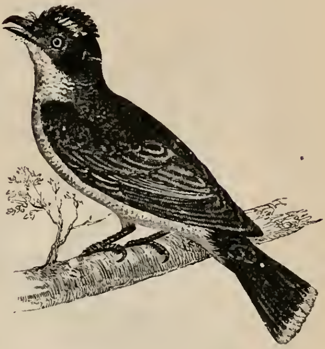


ture of the tarsal envelope, which consists of scutella in the form of cylindrical plates, whose edges come together along a groove toward the hind part of the inner face.

Bird of Paradise, *Paradisœa.*

The Clamatores include the Kingbird, the Great-crested Flycatcher, the Pewees, and all the other numerous members of the family of Flycatchers or Tyrannidæ. They have the bill rather broad, and in most cases bent downward at the tip; and the sides of the mouth are provided with bristles. These birds are of the size of sparrows, or smaller, and constitute a very interesting family.

FIG. 195.



Kingbird, *Tyrannus carolinensis*, Baird.

SUB-SECTION III.

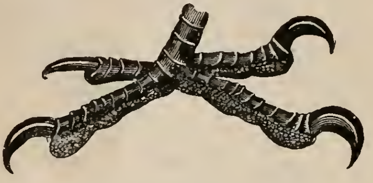
THE ORDER OF PICARIÆ, OR PICARIAN BIRDS.

IN this order or group, ornithologists include a large number of birds of widely different forms, such as Goatsuckers, Chimney Swallows or Swifts, Humming-birds, Trogons, Sawbills, Toucans, Cuckoos, Kingfishers, Woodpeckers, etc.

The group of Picariæ is about equivalent to the old groups Strisores and Scansores—excepting only the Parrots, which are now regarded as constituting an order by themselves.

As a whole, the Picariæ are not easily defined; and, therefore, for our present purposes we will notice merely some of the leading forms separately. It may be stated here, however, that the Picariæ agree in this, that they are alike in differing from all other birds; and in having no highly developed singing apparatus; and in having, in most or all cases, some one of their toes capable of being turned and used in a direction opposite to that which is the usual direction of birds' toes. Those known as Scansores—as Toucans, Cuckoos, Woodpeckers, etc.—have two of the toes directed forward and two directed backward.

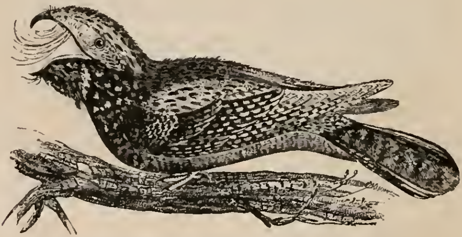
FIG. 196.



Foot of a Picarian Bird Woodpecker,

The Goatsuckers or Caprimulgidæ are such as the Chuckwill's-widow of the Southern States, and the Whippoorwill, and the well-known Night-hawk, etc., all of which have a small triangular bill, enormous gape, large head, and very lax plumage. As to size, they are much smaller than a common dove.

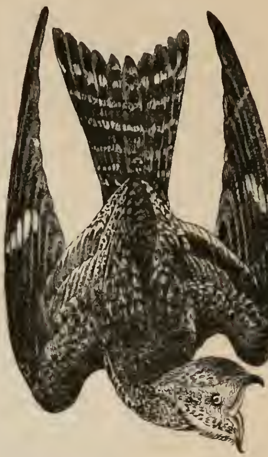
FIG. 197.



Whippoorwill, *Antrostomus vociferus*, Bonaparte.

The notes of the Whippoorwill are three, and have a fancied resemblance to the syllables *whip-poor-will*, and hence its name. During the day the Whippoorwill sleeps upon the ground, or on fallen trunks of trees, or on low branches, and may often be approached to within a few feet before it flies. It is said that it always sits with its body parallel to the branch on which it alights, and never across it. The same is regarded as true of the Night-hawk.

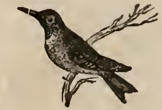
FIG. 198.



Night-Hawk, *Chordeiles popetue*, Baird.

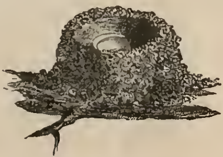
The Humming-birds or Trochilidæ are birds of the smallest size and of the most gorgeous plumage to be found in the feathered race. We might as well attempt to describe the rainbow as the hues of emerald, and ruby, and amethyst, and topaz, and burnished gold which flash from these beautiful forms of life, as they glance among the foliage, or dart from flower to flower seeking their accustomed food. They belong exclusively to the continent and islands of America, and are the most numerous in the hot regions. Some species range north to the Arctic regions, and south to Patagonia,

FIG. 199.



Humming-bird, *Trochilus colubris*, Linn.

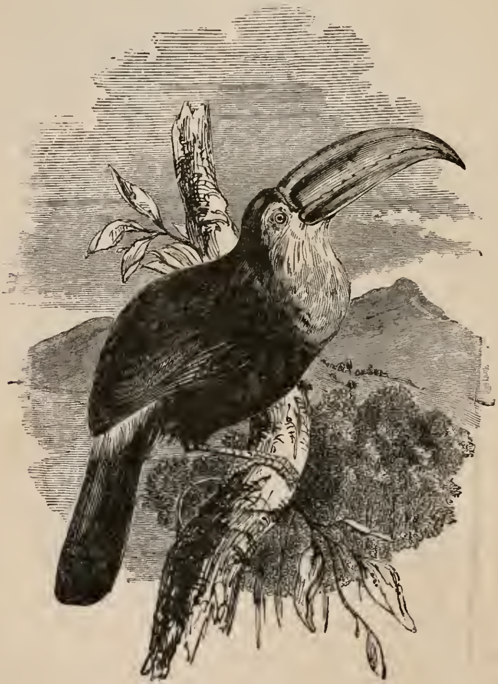
FIG. 200.



Humming-bird's nest, *T. colubris*, Linn.

and from the level of the sea to the cold heights of the Andes. Everything in their organization contributes to give them great power and rapidity of flight; and they are able to balance themselves in the air, or beside a flower, with a facility that is truly wonderful, and which finds a parallel only among some of the insect tribes. Their food consists of insects and honey, which are secured by extending the tongue into flowers without opening the bill very wide. About four hundred species of

Fig. 201.



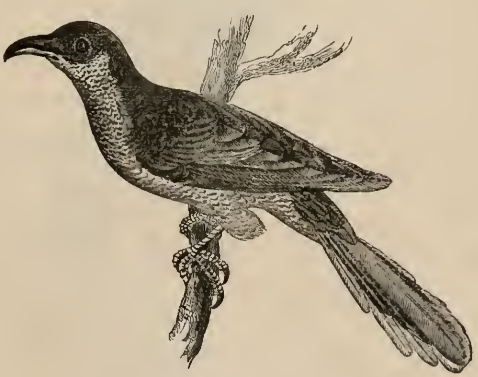
Toucan. *Rhamphastos.*

Humming-birds are known; and six or more are found in North America.

None of the scansorial birds are more remarkable in their appearance than the Toucans or Rhamphastidæ, which have the bill almost as long as the body. The bill is light, being cellular in its structure, and is serrated on its edges. Toucans have a long tongue which is barbed on both edges. They inhabit warm countries, and are about the size of a dove, but more slender.

The Cuckoos or Cuculidæ are scansorial birds which have a gently curved bill, long body, long tail, and rather long tarsi. They vary in size from that of the Yellow-billed Cuckoo (Fig. 202), twelve inches in length, to that of the curious Chapparal Cock or Roadrunner (*Geococcyx californianus*), which is found in the south-western portions of our country, and which is about twenty-four inches long, its tail being about a foot in length.

FIG. 202.

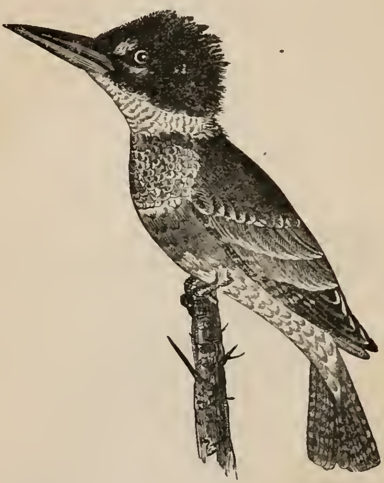


Yellow-billed Cuckoo, *Coccygus americanus*, Bonaparte.

The European Cuckoo is noted on account of its habit of depositing its eggs in the nests of other birds.

The Kingfishers or Alcedinidæ have a very long and acute bill, very short tarsi, and small, syndactyle feet; that is, two of their toes—the third and fourth—are much united. Ponds and slow streams are their favorite resorts, near which they sit on a branch or decayed limb, and watch for fish, which constitute their food. At the proper moment the Kingfisher plunges headlong into the water, seizes the fish, flies to the nearest tree, and swallows its victim in a moment, and is immediately on the watch for another. The Belted Kingfisher is about thirteen inches in length.

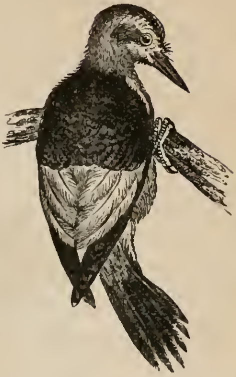
FIG. 203.



Belted Kingfisher, *Ceryle alcyon*, Boie.

The Woodpeckers or Picidæ have a straight, rigid, and sharp bill, which is specially adapted to cutting into bark

Fig. 204.

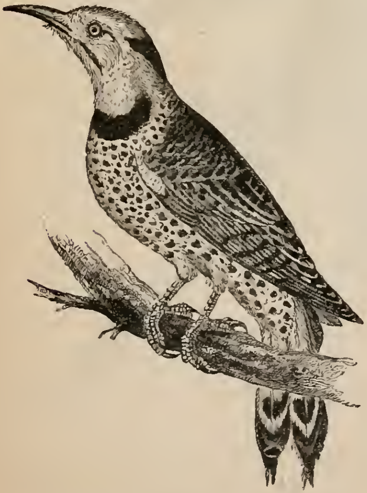


Red-headed Woodpecker, *Melanerpes erythrocephalus*, Swainson.

or wood; and they have a long, acute tongue, armed towards the tip with barbs, and capable of great extention. They have stout feet, long wings, ten primaries, and twelve tail feathers, the exterior being small and concealed. Woodpeckers feed upon the larvæ of insects, which they secure by introducing their extensible tongue under the bark of trees, or into crevices, or into holes which they themselves have made, and then transfixing the larvæ with the barbed point, or the larvæ adhere to the viscid glue with which the tongue is covered.

There are about thirty species in North America, varying from six to twenty or more inches in length. — Some of our most interesting species are the Ivory-billed Woodpecker, and the Red-headed Woodpecker (Fig. 204), and the Golden-winged Woodpecker (Fig. 205).

Fig. 205.



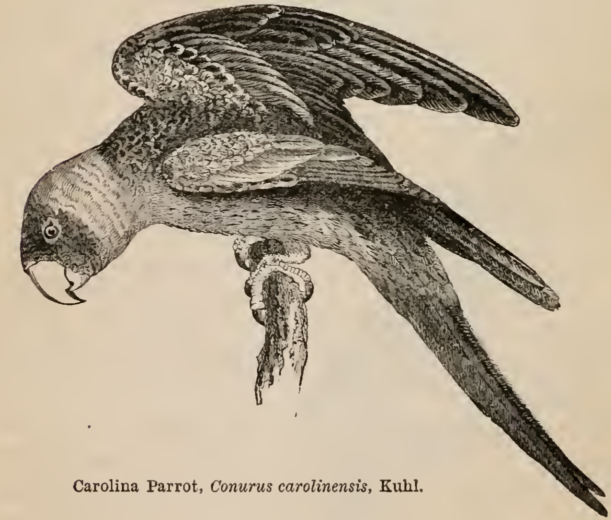
Golden-winged Woodpecker, *Colaptes auratus*, Swainson.

SUB-SECTION IV.

THE ORDER OF PSITTACI OR PARROTS.

THE Parrots, Macaws, Cockatoos, and Paroquets, have a stout, hooked, somewhat hawk-like bill, and the base covered with a soft skin called cere. Their tongue is thick and fleshy, and their inferior larynx is complicated in its structure. They vary in size from that of a sparrow to the size of common dove, or larger, and most of them are adorned with varied and gorgeous plumage.

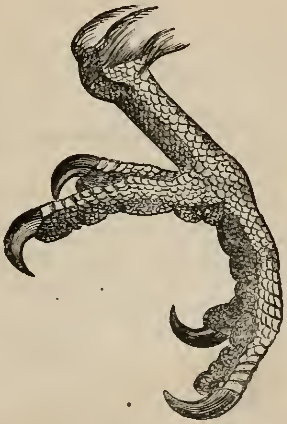
FIG. 206.



Carolina Parrot, *Conurus carolinensis*, Kuhl.

Parrots were formerly included in the old order Scansores, being allied to that group by the nature of their feet, as they have two toes in front and two behind, the outer forward toe being directed backward.

FIG. 207.



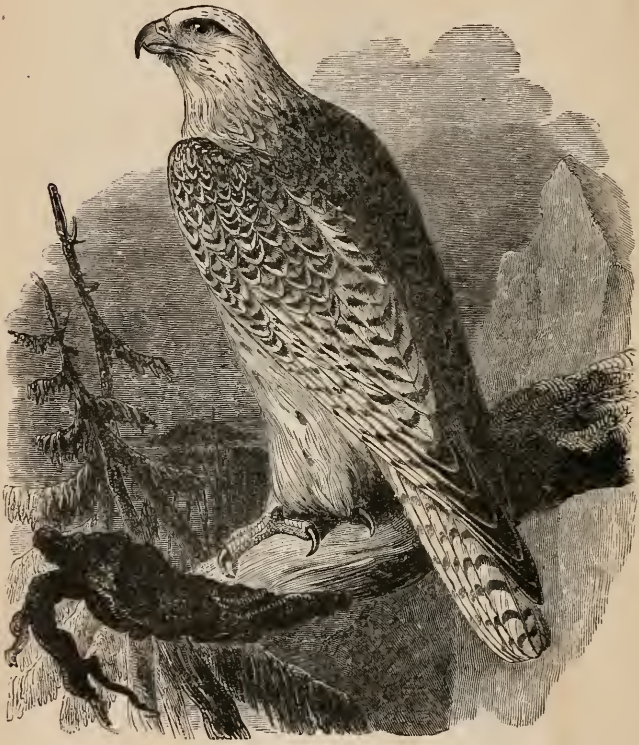
Foot of a Parrot.

SUB-SECTION V.

THE ORDER OF RAPTORES OR BIRDS OF PREY.

THE birds of this order, with few exceptions, are adapted for pursuing and capturing other birds and other animals for food. In general they are of comparatively large size, and have strong, hooked bills, sharp claws, great extent of wing, and powerful muscles; and the females are generally larger than the males. They live in pairs, and are said to choose their mates for life. The plumage of the young and immature individuals differs greatly from that of the adult. The Falcons, Hawks, and Eagles are the typical rapacious birds, and constitute the great family of Falconidæ.

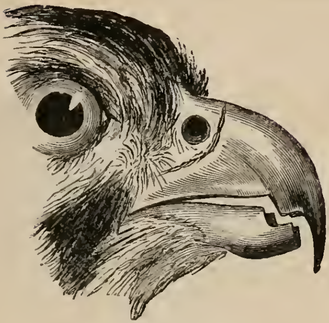
FIG. 208.



Bird of Prey. Gerfalcon, *Falco icelandicus*, Sabine.

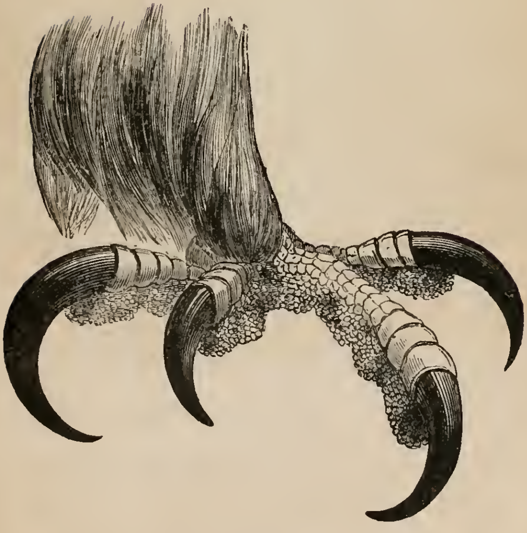
The true Falcons (*Falco*), as the Gerfalcons (Fig. 208)

FIG. 209.



Bill of a Bird of Prey.

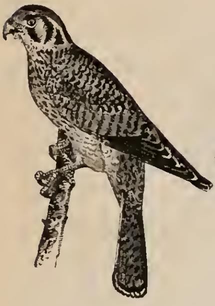
FIG. 210.



Foot of a Bird of Prey.

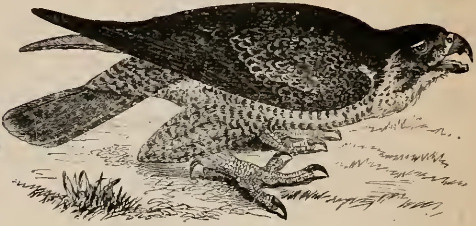
of the cold regions—the birds celebrated from their use in the cruel sport of falconry—the Peregrine Falcon or Duck Hawk (Fig. 212), the Pigeon Hawk, the Sparrow Hawk (Fig. 211), etc., have the upper mandible distinctly toothed, as seen in Fig. 212. The true Falcons are remarkable for exceedingly rapid flight, and for great boldness in attacking their prey. The Duck Hawk is one of our most interesting species. This falcon pursues its prey with almost inconceivable velocity through all its turnings and windings, and when within a few feet of the intended victim protrudes its legs and talons to their full extent, almost closes its wings for a moment, and the next instant grasps the prize, and bears it away.

FIG. 211.



Sparrow Hawk, *Falco sparverius*, Linn.

FIG. 212.



Duck Hawk, or Peregrine Falcon, *Falco anatum*, Bonaparte.

The members of the Falconidæ which are properly called Hawks, do not have the upper mandible toothed, although in most, or at least in many cases, they have this mandible lobed. Such are the Goshawk, Cooper's Hawk, Sharp-shinned Hawk, Red-tailed Hawk, Red-shouldered Hawk, etc. Although many of these are very rapacious, they are not regarded as having comparatively so great strength, swiftness of flight, and courage, as the true Falcons already noticed.

About seventy species of the Falconidæ are known as Eagles. Among the most interesting species are the Golden or Ring-tailed Eagle, the White-headed Eagle—often incorrectly called the *Bald* Eagle—and the Osprey or Fish Hawk. The Golden Eagle has its tarsi feathered, even to the toes.

The White-headed Eagle (*Halietus leucocephalus*, Savigny, Fig. 213) has the *tarsi mostly bare of feathers.* This Eagle frequents the sea-shore, lakes, and rivers, and feeds upon fish. It builds its nest on a tall tree; while the Golden Eagle builds its nest upon a rocky cliff.

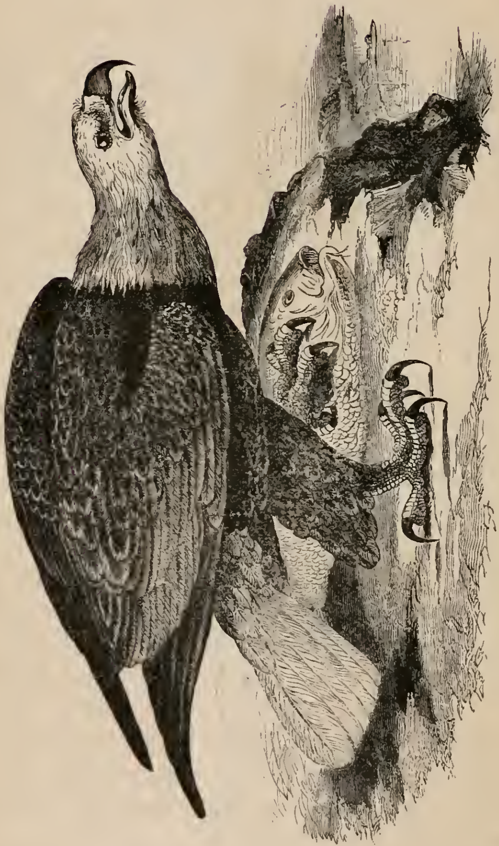
Among all the rapacious birds, none are more remarkable in their appearance than the Owls or Strigidæ. These birds have a comparatively short body, very loose plumage, very large head, very large eyes directed forward, a curved bill nearly concealed by bristle-like feathers, and large ear cavities; and the whole expression of the face is decidedly cat-like.

About a hundred and fifty kinds are known, and excepting the Snowy Owls, and Hawk-Owls, which have the general appearance and habits both of owls and falcons, they are mostly nocturnal in their habits, being abroad at twilight and at night, and keeping quiet during the day.

In size, the Owls vary from the little Acadian Owl, scarcely larger than a robin, to the large Snowy Owls, and the Great Horned Owls, which have a total length of about two feet (Figs. 214, 215).

The smaller kinds of owls prey upon insects, mice, squirrels, and small birds; but the larger kinds attack hares, and grouse; and not unfrequently visit the farm-

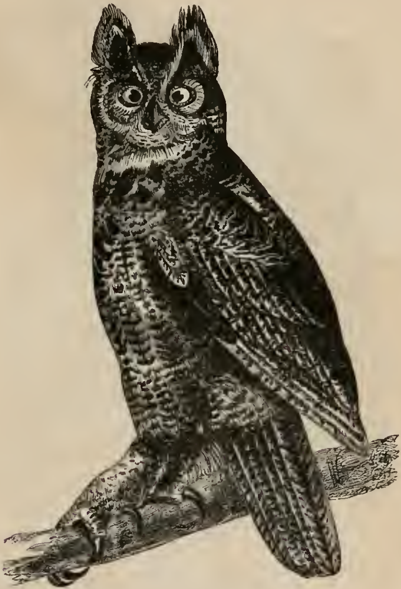
Fig. 213.



White-headed Eagle, *Halietus leucocephalus*, Savigny.

yards and make havoc among the poultry. And the Snowy Owl captures ducks and other birds upon the wing, striking them much after the manner of a falcon.

FIG. 214.



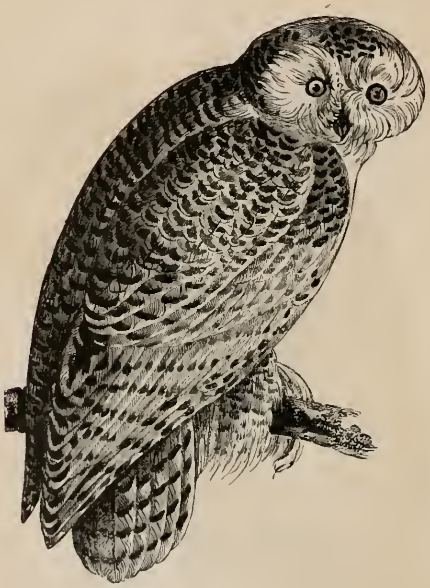
Great Horned Owl, *Bubo virginianus*, Bonaparte.

The tremulous and doleful notes of the little Mottled or Screech Owl, the prolonged and painful cry of the Long-eared Owl, the grating noise of the little Acadian or Saw-whet Owl, are sounds most unwelcome to him who has not yet learned the harmless nature of the beings from which they come.

Most kinds of owls spend the day in the thick forests, among the thick foliage, and not unfrequently in a hollow tree. The little Burrowing Owl of the High Central

Plains of our country, lives in the burrows of the Prairie Dog, where it is doubtless an unwelcome visitor.

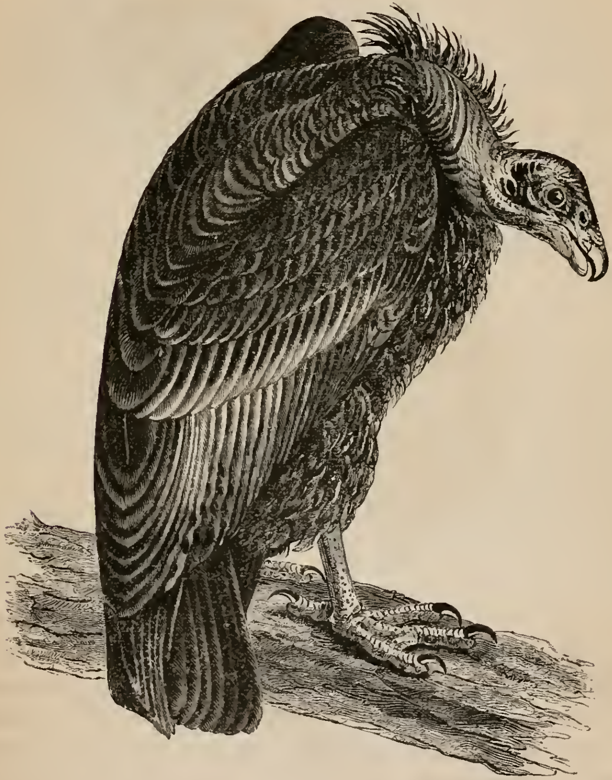
Fig. 215.



Snowy Owl, *Nyctea nivea*, Gray.

Of all the birds included in the Order of Raptores, none are of less popular interest—taken together as a family—than the Vultures or Vulturidæ; although there are a few very interesting species, as the Condor, of South America, and the Lammergyer, of the Alps. The Vultures have the eyes on a level with the sides of the head, and the head and upper part of the neck naked. Excepting the Condor and Lammergyer, and a few others, they are the feeblest representatives of the rapacious birds. They seldom capture their food unless forced to do so by hunger; they prefer to feed on dead and decaying animals which they chance to find. In a word, they are the scavengers among Birds, as the Hyenas are among Mammals.

FIG. 216.



California Vulture, *Cathartes californianus*, Shaw.

They are often called Buzzards, and are the most numerous in warm countries, where they serve a most important purpose in removing dead and decaying animals. The

California Vulture, is the largest rapacious bird in America, except the Condor, having a total length of about fifty inches.

SUB-SECTION VI.

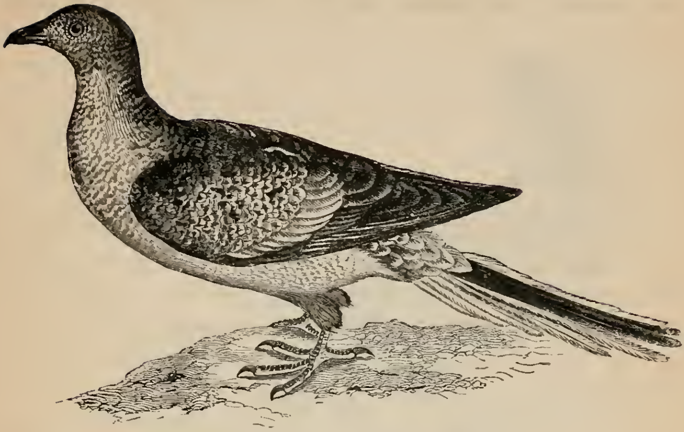
THE ORDER OF COLUMBÆ OR PIGEONS AND DOVES.

THE name of this order is from the Latin word *columba*, a pigeon. The Columbæ are birds which have the bill shorter than the head, the basal portion covered by a soft skin in which the nostrils are situated, the hind toe on the same level as the others, and the anterior toe without a basal membrane. They live in pairs, lay two eggs for a brood, but breed often, and feed their young with macerated food from their own crops.

The common domestic Doves and Pigeons, the Wild Pigeons, the Turtle Doves, etc., which together constitute the family of Columbidæ, are familiar examples of this interesting order.

The Wild or Passenger Pigeon, of North America, is seventeen inches long, and has the upper parts blue, under parts mainly purplish-red, and the sides and back of the neck a glossy golden-violet. This Pigeon is extremely rapid in flight, being able to perform a long journey at an average speed of a mile a minute! The migrations are for the purpose of procuring food, and hence do not take place at any particular season of the year. Millions of pigeons often associate in a single roost, completely filling a forest for thirty or forty miles in length and several miles in breadth, and literally loading and breaking down large trees. From their roosts they fly off hundreds of miles, in some cases, to feeding-grounds, and return at

FIG. 217.



Wild Pigeon, *Ectopistes migratoria*, Swainson.

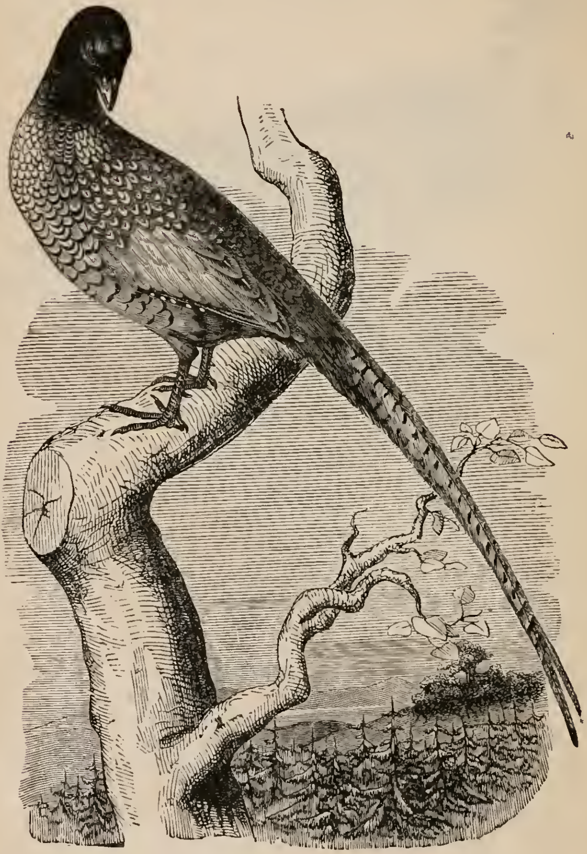
night. Sometimes, in their migrations, they fill the air like a cloud, and thus continue to pass for a whole day, and even for two or three successive days! The nest is built on a tree, and is composed of a few dry sticks and twigs, and more than a hundred nests are sometimes placed on a single tree.

SUB-SECTION VII.

THE ORDER OF GALLINÆ, OR PHEASANTS, ETC.

THE birds included in the order of Gallinæ—from the Latin *gallus*, a cock—have the bill short, stout, and hard; the legs rather long; the hind toe in most cases more or less elevated; and the toes connected at their base by a membrane; and their young are able to run about and pick up food as soon as hatched.

Fig. 218.



Pheasant, *Phasianus colchicus.*

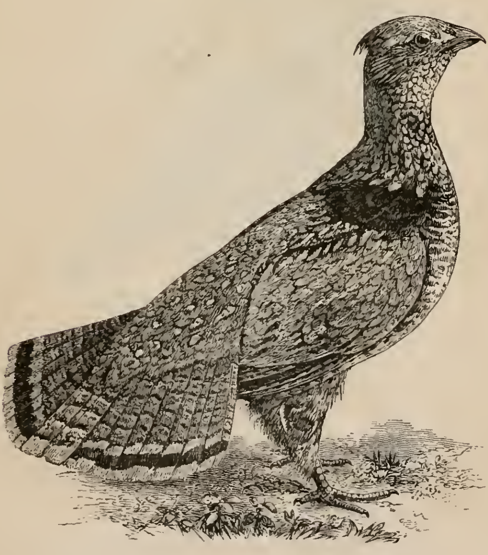
To this order belong the Pheasants, the common domestic fowls, and their wild allies; also the Grouse, the Quails, etc.

The Jungle Fowls of India, the common cock and hen, the Turkeys, the Peacocks, the Pheasants, etc., belong to one great family—the Phasianidæ.

The Grouse or Tetraonidæ are gallinaceous birds which have the nasal fossæ filled and covered with feathers, the tarsi more or less feathered, and the toes pectinated along their edges. The Prairie Chicken, the Ruffed Grouse, the Sage Cock, and Spruce Partridge are among our most interesting species. Here also belong the Ptarmigans of the cold northern regions.

The Ruffed Grouse, or "Partridge," of the United States is about eighteen inches long, and the color is reddish-brown or gray above, the back with spots of

FIG. 219.

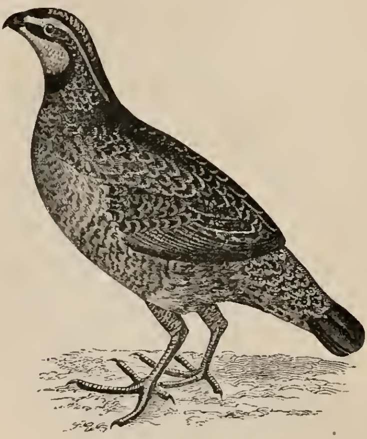


Ruffed Grouse, *Bonasa umbellus*, Stephens.

lighter; the under parts whitish, barred with dull brown. The feathers of the ruff are black; the beautiful tail is tipped with gray, and has a subterminal bar of black. The Ruffed Grouse walks with a proud step, elevated head, the ruffs more or less raised, and its exquisitely beautiful tail partly spread. It takes wing with the loud whirring which all have heard who have had the pleasure of visiting its favorite resorts.

The Quails or Perdicidæ are birds which differ from the grouse in being much smaller, and in having bare tarsi, and naked nasal fossæ.

Fig. 220.

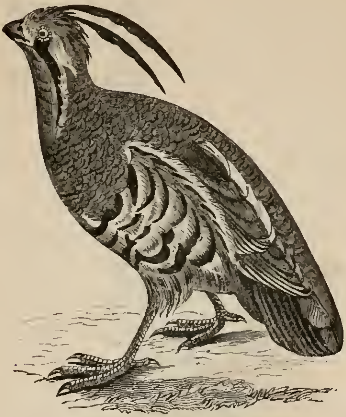


Quail, *Ortyx virginianus*, Bonaparte.

The Quail or Bob White of the United States is ten inches long, and the prevailing color above is brownish-red; the under parts are white, tinged with brown before, and marked with obtusely V-shaped spots of black; the head is beautifully marked with pure white and black.

The Mountain Quail, of the mountain ranges of Oregon and California, has long plumes, as in Fig. 221; and the California Quail has a crest of lengthened feathers whose shafts are in the same vertical plane, and which point forward.

FIG. 221.



Mountain Quail, or Plumed Partridge, *Oreortyx pictus*, Baird.

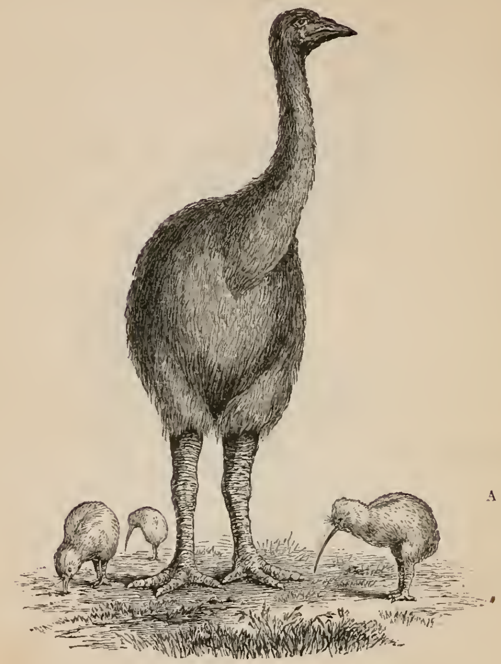
SUB-SECTION VIII.

THE ORDER OF BREVIPENNES OR OSTRICHES.

THESE are birds of great size, with the neck and legs very long, and the wings rudimentary. They cannot fly, but they run with great speed. The name Brevipennes is from the Latin *brevis* short, and *penna*, a feather or wing.

The Brevipennes are the Ostriches of the deserts of Africa and Asia, the Emeus or Cassowaries—Ostrich-like birds of the Indian Archipelago and of Australia,—the Apteryx of New Zealand, and various fossil forms.

FIG. 222



Moa or Dinornis (*D. giganteus*), restored; and three individuals of the Apteryx (A).

The African Ostrich carries its head about eight feet high. Its feet are two-toed, and the outer toe is destitute of a nail. It is so swift of foot that no animal can overtake it in running. Its eggs weigh about three pounds each!

The South American Ostrich or Rhea is a much smaller bird, and has three toes, each provided with a nail.

The Apteryx has the wings so rudimentary that they are wholly concealed by the feathers of the body, and appear to be useless even as an aid in running. Each wing is terminated by a hooked claw. The bill of the Apteryx is long and slender, and the nostrils are at its tip.

Of the fossil forms of Brevipennes or Ostrich-like birds, the Moa, Palapteryx, Notornis, and Æpyornis may be mentioned here.

The Moa (*Dinornis giganteus*) of New Zealand was much larger than any living ostrich, being twelve or more feet in height. Its tibia was thirty-two inches long! And its eggs were so large that Mr. Walter Mantell, who first found them, states that his hat would just serve as an egg-cup for one of them!

The Æpyornis was found in Madagascar, and from its bones it is estimated to have been twelve feet high. Its egg, also found fossil, is thirteen and a half inches in its longest diameter!

SUB-SECTION IX.

THE ORDER OF LIMICOLÆ OR SHORE BIRDS.

THIS order, and the two following ones, namely, Herodiones or Herons, and Alectorides or Rails, etc., constitute the old group Grallatores.

The name Limicolæ comes from the Latin *limus*, slime or mud, and *colere*, to inhabit. Many of these birds frequent muddy shores.

This order, as here limited, includes the Bustards, the Plovers, Turnstones, Stilts, Phalaropes, Woodcocks, Snipe, Sandpipers, Yellow-legs, Curlews, etc.

The Limicolæ have a slender bill, which, in most cases, is mainly covered with a rather soft skin or membrane, and which is more or less sensitive even to its tip. In most species the wings are long and pointed, the legs long and slender, the toes comparatively short, the anterior toes in many species semipalmate, and the hind one short and elevated or wholly wanting.

The Limicolæ generally lay four eggs in a rude nest or depression in the ground, and the young are covered with a sort of down, and are able to run as soon as hatched.

The Bustards, or Otididæ, belong to the Eastern hemisphere, and have a large body, similar to that of the Gallinæ, a long neck and legs somewhat like those of the Ostriches, and toes similar to those of the Plovers. The Great Bustard is the largest bird of Europe, being four feet in length.

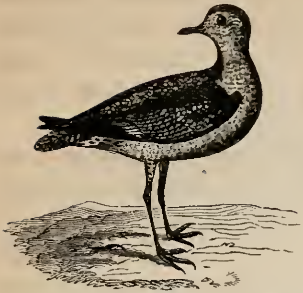
The Plovers (Fig. 223), or Charadriidæ, have the bill somewhat in the form of a pigeon's, a stout body, long and pointed wings, and reticulate tarsi. Plovers vary from six to twelve inches in length.

The Oyster-catchers and the Turnstones (Fig. 224) or Hæmatopodidæ, have the bill acute in one genera, truncate in another, and in all cases hard, and the legs short and brightly colored. Those with a truncate bill pry open the shells of bivalve mollusks to eat the animal; those with an acute bill turn over pebbles in search of food. The most common species (Fig. 224) is about eight inches long.

The Stilts and Avocets, or Recurvirostridæ (Fig. 227), have extremely long legs, webbed or semipalmate feet, and a long and slender bill which is either nearly straight, or recurved. These birds are from thirteen to eighteen inches in length.

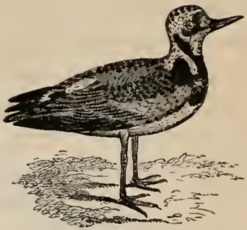
The Snipes, or Scolopacidæ (Figs. 225–6), have the bill extremely long, slender, grooved, and sensitive. Their

FIG. 223.



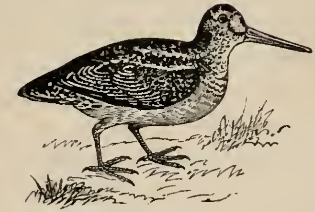
Golden Plover, *Charadrius virginicus*, Borck.

FIG. 224.



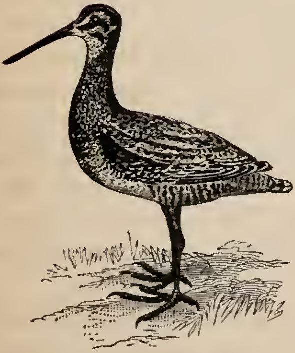
Turnstone, *Strepsilas interpres*, Illiger.

FIG. 225.



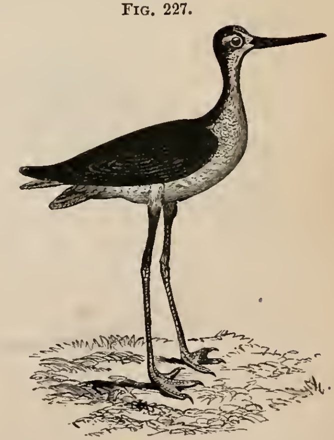
American Woodcock, *Philohela minor*, Gray.

FIG. 226.



Wilson's Snipe, *Gallinago Wilsonii*, Bonaparte.

FIG. 227.



Black-necked Stilt, *Hæmatopus nigricollis*, Vieillot.

tarsi, in most cases, are scutellate before and behind, and reticulate on the sides. Their extremely sensitive bill enables them readily to find worms and other small animals, by probing in the sand and mud. The young are able to run as soon as hatched.

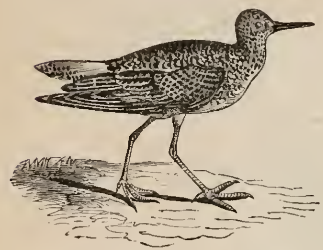
The Woodcocks (Fig. 225), and true Snipe (Fig. 226), are from nine to twelve inches in length, and have the bill perfectly straight.

The Godwits (Fig. 229), are sixteen or more inches in length, and have the bill slightly curved upward.

The Sandpipers vary from six inches to a foot or more in length, and have the bill relatively short. They are abundant on all shores. The little semipalmated Sandpiper or Peep (*Ereunetes pusillus*) is a well-known representative of this division.

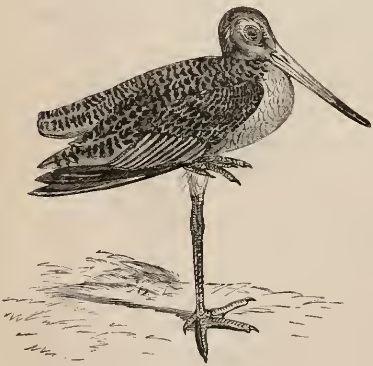
The Tattlers are noisy birds, which have a rather long bill, long body, the toes with a basal web, and the hind toe always present. The Yellow-legs (see Fig. 228) is a well-known example.

Fig. 228.



Yellow-legs, *Gambetta flavipes*, Bonaparte.

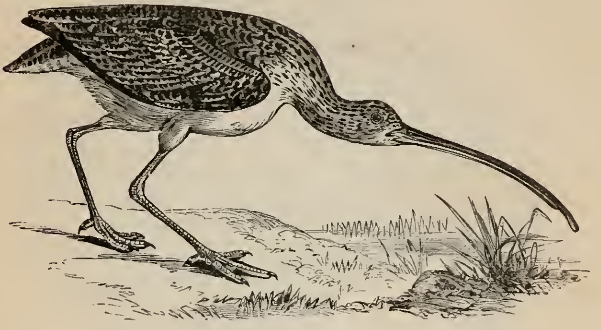
Fig. 229.



Marbled Godwit, *Limosa fedoa*, Ord.

The Curlews (Fig. 230) vary from twelve to twenty-four inches in length, and are at once distinguished by their extremely long and downward curved bill, which in the species here figured (Fig. 230) sometimes attains the length of nine inches!

FIG. 230.



Long-billed Curlew, *Numenius longirostris*, Wilson.

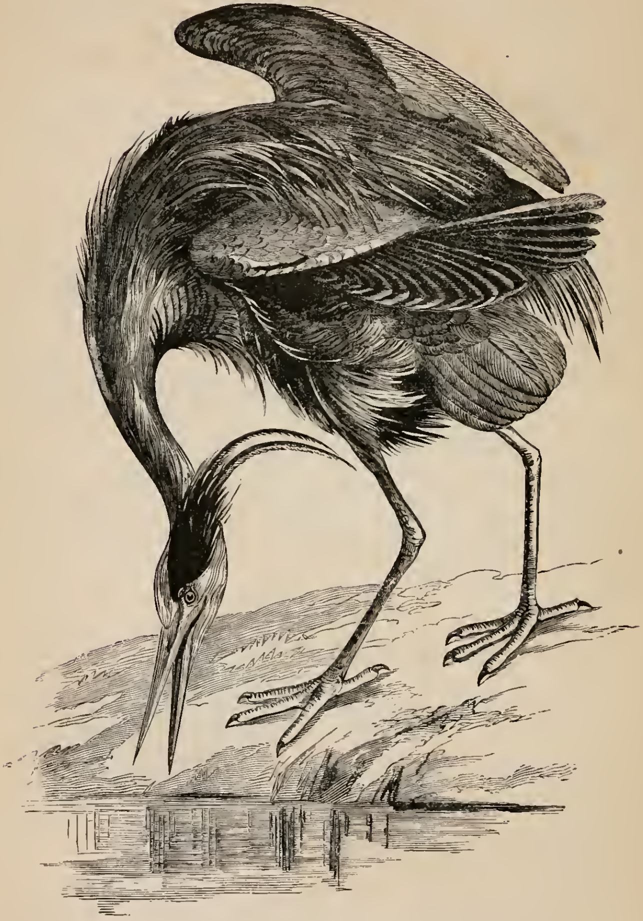
SUB-SECTION X.

THE ORDER OF HERODIONES OR HERONS, ETC.

THE Grallatores of this order have the bill, neck, and legs extremely long, and the body, in most cases, much compressed. The toes are four in number, and are long and slender.

The Herodiones readily perch on trees, and there they build their nests. The young hatch in a feeble condition, and are fed for a long time in the nest. They feed upon fish, frogs, etc., which they pierce with their sharp-pointed bill.

Fig. 231.

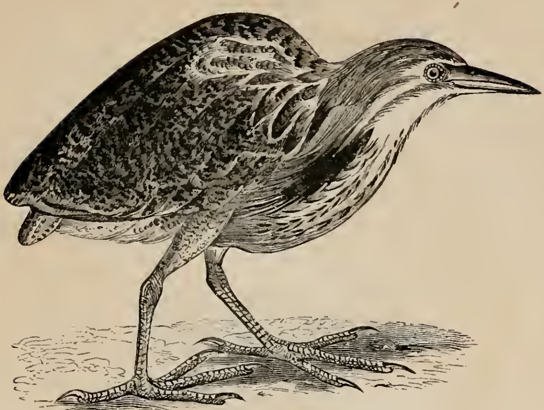


Great Blue Heron, *Ardea herodias*, Linnæus.

This group includes Herons, Storks, Ibises, Spoonbills, etc.

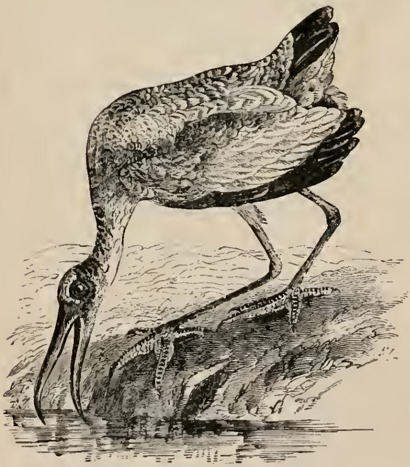
The true Herons or Ardeidæ, have the bill extending

FIG. 232.



Bittern or Stake-driver, *Botaurus lentiginosus*, Stephens.

FIG. 233.



Wood Ibis, *Tantalus loculator*, Linn.

back to the eyes, wings broad, tail short, middle claw pectinate, the plumage loose, and "powder-down" tracts present in two or more pairs. Here belong the Great

Blue Heron (Fig. 231), forty-two inches long, the Night Heron, the Bittern (Fig. 232), etc.

The Ibises or Tantalidæ have the bill rounded and much decurved, and the toes have a basal web. The Wood Ibis of the Southern States is forty-five inches long.

The Spoonbills or Plataleidæ are large grallatores whose bill is completely flattened and very broad, and widening at the rounded tip. Our only species is the Rosy Spoonbill of the Southern States.

SUB-SECTION XI.

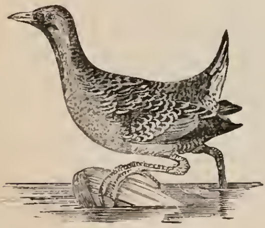
THE ORDER OF ALECTORIDES OR RAILS, ETC.

THE Cranes and Rails are included in this group, according to the later views in ornithology, although the Cranes have a marked resemblance to the Herons. The name Alectorides is probably from the Greek *alectōr*, a cock, and *eidos,* form, alluding to a fancied resemblance.

The Cranes or Gruidæ greatly excel even the Herons in height. The Whooping Crane (*Grus americanus*), and the Sandhill Crane (*G. canadensis*) are our only species.

The Rails or Rallidæ have a compressed body, rather short bill, very short concave wings, a turned-up tail, large legs, and exceedingly long toes, which enable them to run over soft ground, and even on the surface of broad floating leaves like those of water-lilies and other aquatic plants.

FIG. 234.

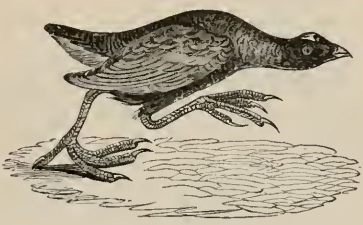


Common Rail, *Porzana carolina,* Vieillot.

Rails are mostly of small size, varying from five or six inches to eight inches in length. The Clapper Rail or Marsh Hen, however, is sixteen inches long.

In the family of the Rallidæ are also included the Coots, which have the bill extending into the feathers of the forehead, where it forms a wide plate, and which have the toes margined with semicircular lobes. Here also belong the Gallinules (Fig. 235), which have enormous feet, but no lobes on the toes.

FIG. 235.



Purple Gallinule, *Gallinula martinica*, Latham.

SUB-SECTION XII.

THE ORDER OF LAMELLIROSTRES OR GEESE, DUCKS, ETC.

THIS group, and the four following—namely, the Steganopodes, Longipennes, Pygopodes, and Sphenici—constitute the great group of Swimming Birds or Natatores.

The Natatores are birds which, by their whole structure, are specially fitted for living in the water. They are broad, depressed, and flattened below; their plumage is compact, and kept well oiled; the legs are widely separated, and the femur is short, bringing the knee within the general skin of the body; and the feet are webbed.

The natatores which compose the group of Lamellirostres have both mandibles furnished along their edges with lamellæ or plates, which appear like teeth-like projections.

The name comes from the Latin *lamella*, a plate, and *rostrum*, a beak.

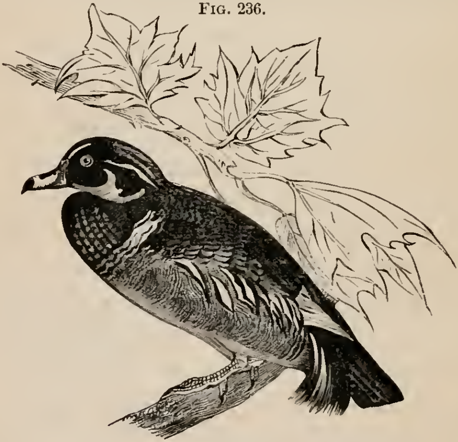
In this group or order belong the Flamingoes, Geese, Swans, and Ducks.

The Flamingoes are at once distinguished by their exceedingly long neck and long legs—by which they seem related to the Herons—and their very large bill which is abruptly bent downward in the middle. They are found on the Gulf of Mexico, and are about four feet long.

The Swans, Geese, and Ducks, or Anatidæ, have the bill elevated and compressed at the base, and covered with a leather-like membrane, excepting the end, which is covered with a hard horny portion called the nail. The Swans have a portion of bare skin between the eye and the bill; and are very large, having a length of four feet.

The Geese have no bare skin between the eye and the bill.

Fig. 236.



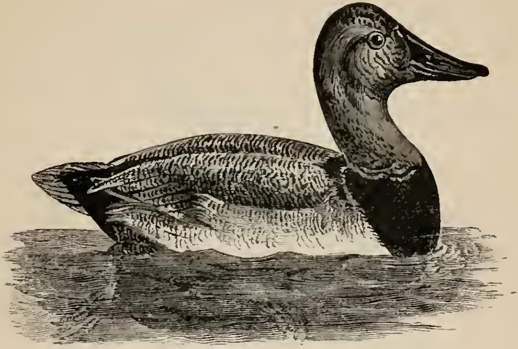
Summer or Wood Duck, *Aix sponsa*, Boie.

The River Ducks, as the Mallards, Black Duck, Pintail, Gadwalls, Widgeon, Teal, Shoveler, and Wood

Duck, have the tarsi scutellate, and the hind toe simple.

The Sea Ducks have the hind toe lobate, that is, furnished with a large membranous appendage, and their feet are very large, tarsi very short, and the webs of the feet *very broad*. The Red-head, Canvas-back, Golden-eye, Harlequin, Eider, etc., are well-known examples.

FIG. 237.



Canvas-back, *Aythya vallisneria*, Bonaparte.

The Mergansers are fishing ducks which are at once distinguished from all others by their cylindrical bill, and their prominent teeth-like lamellæ, which point backward. They pursue and capture fish under water.

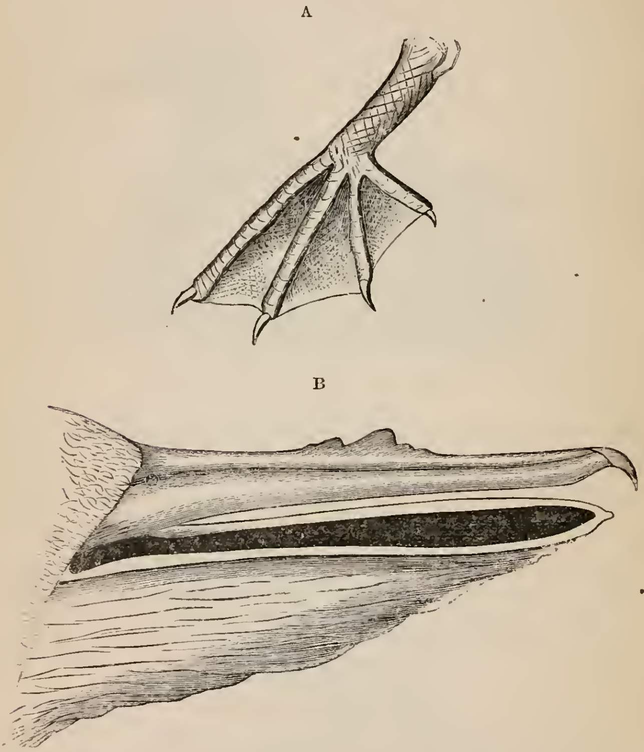
SUB-SECTION XIII.

THE ORDER OF STEGANOPODES OR TOTIPALMATE BIRDS.

THE name Steganopodes comes from the Greek word *steganos*, covered, and *pous*, *podos*, the foot, and is applied to Gannets, Pelicans, Cormorants, Snake-birds, Man-of-war

Birds, etc., all of which have the feet totipalmate, that is, furnished with three full webs. In all these the hind toe is low down and more or less turned to one side, and is connected with the inner toe by a complete web. The birds of this order are hatched in a feeble condition, and require feeding by the parents.

FIG. 238.



A, Totipalmate foot. B, Bill and Gular pouch of a Pelican.

The Gannets or Sulidæ are sea-birds which are goose-like in their appearance, and which are remarkable for obtaining their prey—consisting of fishes—by plunging into the water from a considerable height.

The Pelicans or Pelicanidæ are very large birds, remarkable for their enormously long and large bill, which is a foot or more in length, and for their enormous gular pouch, which in some species will hold a gallon! The gular pouch is used by the bird as a fish-net to scoop up fish with.

The Cormorants or Graculidæ have a very long bill, strongly hooked at the end, green eyes, long neck, compact body, and legs set far back. They swim under water in pursuit of fishes, upon which they feed.

The Snake-birds or Anhingas or Plotidæ have a long slender bill, an exceedingly long and slender neck, and a rather slender body. A single species about three feet long is common in the Southern States.

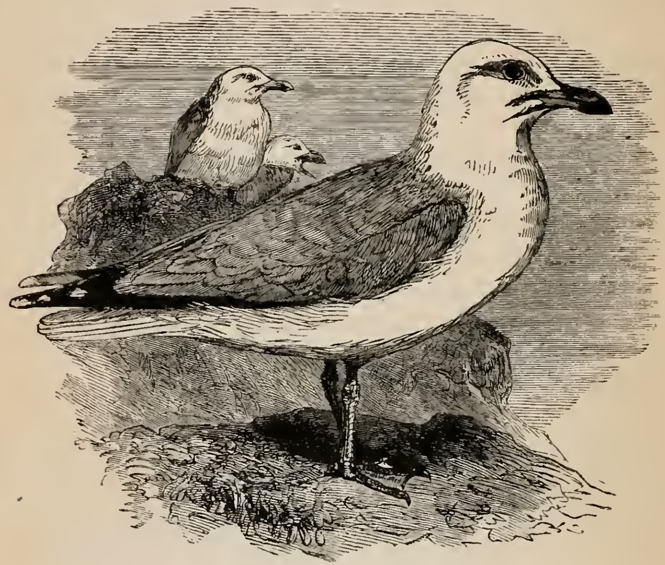
The Frigate or Man-of-war Birds or Tachypetidæ are sea-birds remarkable for their long bill, exceedingly long and pointed wings, long and forked tail, small feet, and for their wonderful power of flight. They are about three feet long, and have an extent of wings about eight feet.

SUB-SECTION XIV.

THE ORDER OF LONGIPENNES OR LONG-WINGED SWIMMERS.

GULLS, Terns, Albatrosses, Petrels, etc., are the birds which constitute the order of Longipennes or Long-winged birds, as the name indicates. All these have the wings long and pointed, the body well balanced upon the legs, the anterior toes webbed, and the bill furnished with a heavy covering; and the bill is never lamellate, as in the geese and ducks.

Fig. 239.



Herring Gull, *Larus argentatus*, Linn.

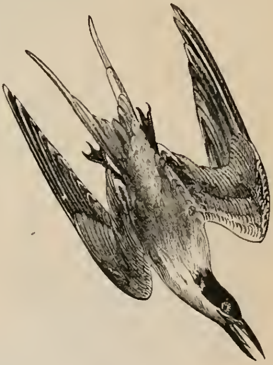
Those longipennes whose nostrils are not tubular are called Gulls and Terns, and constitute the family of Laridæ; those with tubular nostrils are the Albatrosses and Petrels, and constitute the family of Procellaridæ.

Some kinds of gulls have the bill provided with a horny cere, beneath the edges of which the nostrils open; and they have the tail nearly square. These are the Skua Gulls or Jaëgers, which are rapacious in their habits. They belong mainly to the northern regions.

The ordinary Gulls (*Larus, etc.*) have the bill wholly horny, compressed, and the upper mandible longer than the lower, and its tip more or less bent downward. The ordinary Gulls are mainly white with a darker-colored mantle. They vary from twelve to thirty inches in length. They feed upon fishes and upon all other kinds of animal food which they can secure, and they pick up all kinds of food which they find floating upon the water.

The Terns have the bill rather long, slender, and acute, the mandibles of nearly equal length, the wings extremely long and pointed, the tail generally forked, and the feet very small. They are much more beautiful in their form and more graceful in their movements than the Gulls, and they are often called Sea-Swallows. They feed upon fish, which they dart down upon in the water, and upon insects, which they capture on the wing. Most species of Terns are white, often of a rosy hue below, with a black cap on the head, and with a pearly-colored mantle. Terns vary from eight to twenty inches or more in length.

FIG. 240.

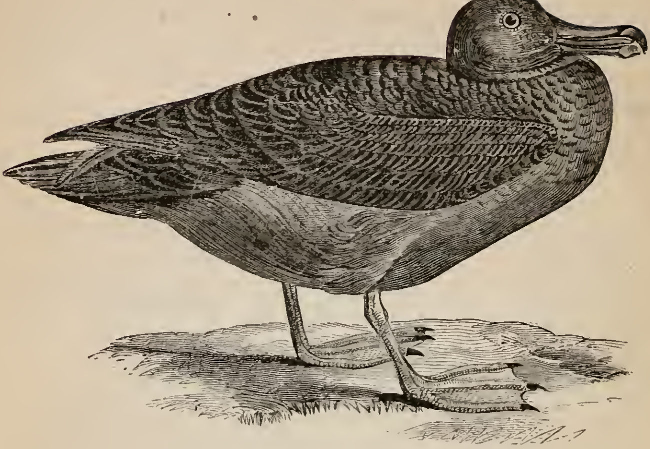


Roseate Tern, *Sterna paradisea*, Brünnich.

The Albatrosses and the Petrels have the bill rather long, compressed, and deeply grooved, and appearing as if formed of several distinct parts; and the nostrils opening from distinct tubes, as already stated.

The Albatrosses (*Diomedea*) have the nostrils placed near the base of the bill, one nostril on each side, and they have no hind toe. They inhabit the shores and

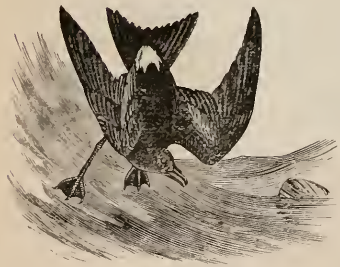
FIG. 241.



Sooty Albatross, *Diomedea fuliginosa,* Gmelin.

islands of the Pacific, and are the largest of swimming birds, being bulky, and having a length of forty inches or more.

FIG. 242.



Petrel, *Thallassadroma Leachii,* Temmnick.

The Petrels are at once distinguished by their nostrils, which are in the form of a double tube placed on the top of the bill at its base. Petrels vary in size, from the little Stormy Petrels or "Mother Carey's chickens," which are only about six inches long—the smallest of swimming birds—to the gigantic Fulmars, which are about as large as the Albatrosses.

SUB-SECTION XV.

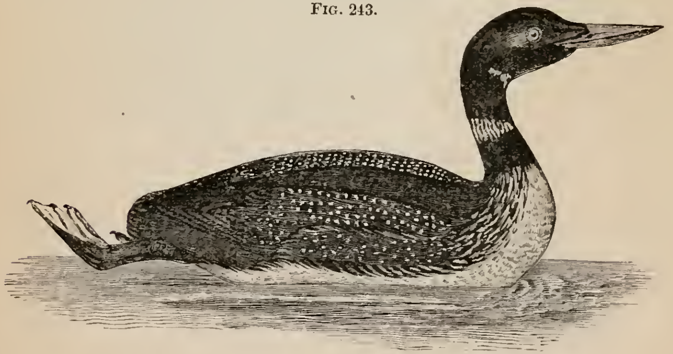
THE ORDER OF PYGOPODES OR DIVERS.

THE Pygopodes are natatorial birds which are more perfectly adapted for a strictly aquatic life than any of the groups which we have already described. They swim and dive with the greatest ease. And they move under water apparently with as great ease as upon the surface; and in moving beneath the surface of the water they use the wings as well as the feet.

The Pygopodes are the Loons, Grebes, Auks, etc., birds which have the feet placed very far back; and hence the name of the order, from the Greek words *puge*, rump, and *pous*, *podos*, a foot. The legs of these birds are placed so far back that they are obliged to stand nearly upright when on the ground, and they walk with great difficulty.

The Loons or Colymbidæ have the bill stout, long, straight, and pointed; and the nostrils linear, with their upper edge lobed. The common Loon or Great Northern

FIG. 243.

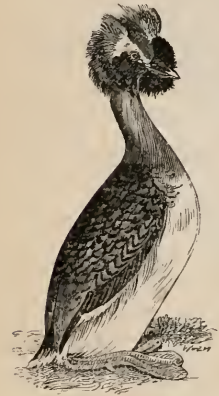


Great Northern Diver, or Loon, *Colymbus torquatus*, Brünnich.

Diver is thirty-one inches long, and its colors are black and white.

The Grebes are very peculiar-looking birds, which have the bill rather long, slender, and pointed, the nostrils not lobed, the wings very short, the tail only a tuft of downy feathers, and the plumage of the under parts white and very silky in appearance, and the feet only partially webbed, and the toes and claws flat. In the breeding season the head in most species is ornamented with tufts of feathers. When alarmed they quietly sink in the water, and there remain, exposing only the bill. They vary from twelve to thirty inches in length.

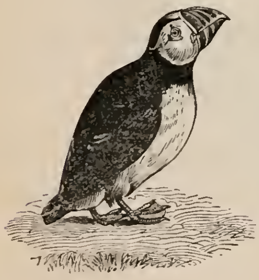
FIG. 244.



Crested Grebe, *Podiceps cristatus*, Latham.

The Auks or Alcidæ are pygopodons birds which have the bill generally pointed, compressed, and in many cases modified by ridges, furrows, and processes, which give it a very odd appearance. They are rather stout-bodied birds; and their wings, tail, and toes are very short. All the species of the Alcidæ belong to the northern regions; some species come far southward in winter. They are known as Auks, Puffins, Guillemots or Murres, according to the kind. They vary from seven to thirty inches in length.

FIG. 245.

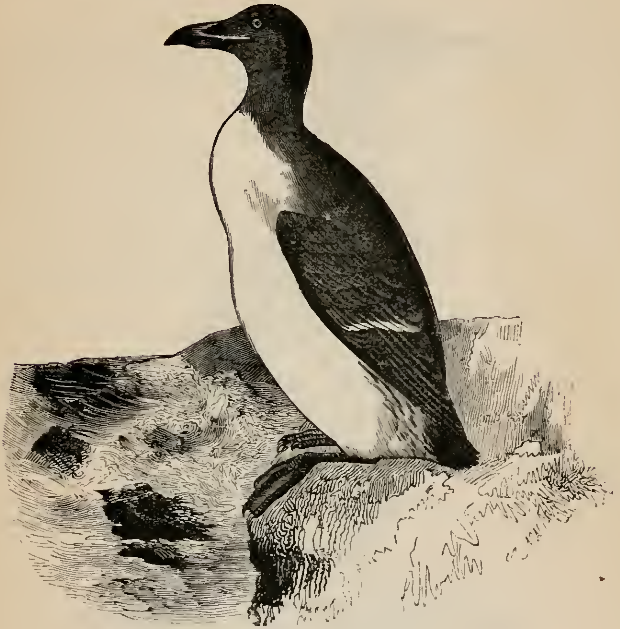


Puffin, *Mormon arctica*, Illigiger.

The Great Auk (*Alca impennis*) is thirty inches long, and the wing only five and a half inches.

It is extremely rare, and is believed to be on the point of extinction. The Razor-billed Auk is found in winter as far south as New Jersey.

FIG. 246.



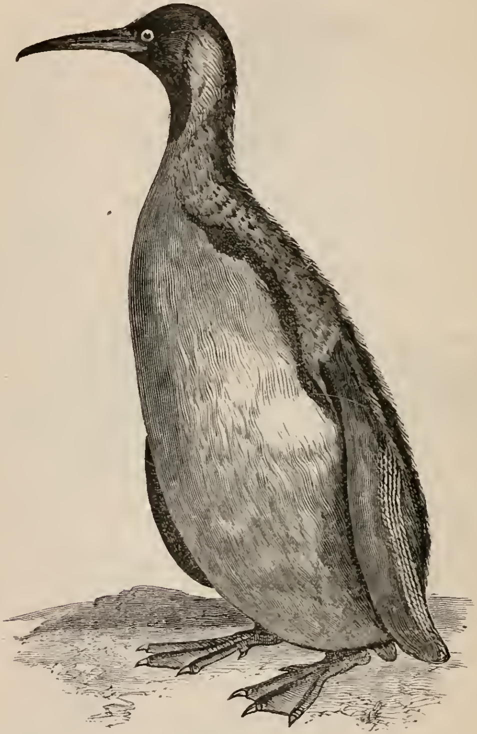
Razor-billed Auk, *Alca torda,* Linn.

SUB-SECTION XVI.

THE ORDER OF SPHENICI OR PENGUINS.

THESE are natatorial birds which cannot fly, the wings being hardly more than mere flippers or paddles, covered with scale-like feathers; and their bones are solid and heavy. They swim with great facility, and use their wings as well as their feet in locomotion under water. Penguins are confined to the cold regions of the Southern hemisphere, and rarely go on shore except to lay their eggs. Some species do not lay their egg in a nest, but carry it about in a sort of pouch on the abdomen!

Fig. 247.



Great Penguin, *Aptenodytes patagonica,* Linnæus.

The Great Penguin is as large as a goose, and of a slate color above, white below, with a large black patch in front, surrounded by a yellow band.

The name of this group—Sphenici—is probably from the Greek *sphēn* a wedge, and has reference, probably, either to the shape of the bill or that of the body, or both.

Fossil remains of birds are found in the rocks as low down as the Jurassic, inclusive; and if the so-called "Bird-tracks," in the sandstone of the Connecticut Valley, are really those of birds, then we may say as low down as the Triassic. Both bones and feathers of birds have been found fossil in the Jurassic rocks at Solenhofen, Bavaria; and the bird represented by these remains has been named the Long-tailed Ancient-Bird (*Archæopteryx macrura*). This bird had well-developed non-anchylosed metacarpal bones, and a tail of twenty vertebræ, with a row of feathers along each side—a pair to each vertebra. The total length of this bird was about two feet. It belongs to the order of Saururæ.

A large number of species of fossil birds have been described by Marsh and Cope from the Cretaceous and Tertiary rocks of the United States. These birds represent the Picariæ, Raptores, Gallinæ, Grallatores, and Natatores. (See Professor Marsh's "Synopsis," etc., in Dr. Coues' "Key.")

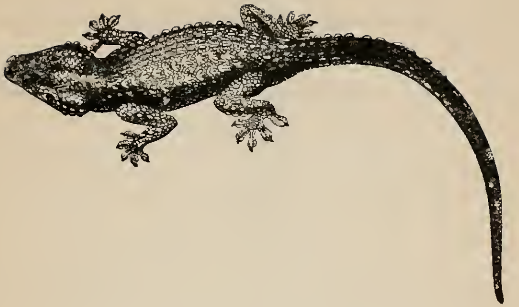
For aid in the study of North American Birds the student is referred to the "*Key to North American Birds*" by Elliott Coues; and to "*A History of North American Birds*" by S. F. Baird, T. M. Brewer, and R. Ridgway.

Principal Topics considered in Chapter II., Section III.

SUB-SECTION I.

The Birds considered as a Class.——Their general characteristics, their external parts, skeleton, internal structure, etc.—Eggs.——Nests.——Longevity.——Classification.

Sub-sections II., III., IV., V., VI., VII., VIII., IX., X., XI., XII., XIII., XIV., XV., and XVI., treat respectively of the Passeres or Song-Birds, etc., the Picariæ or Woodpeckers, etc., the Psittaci or Parrots, etc., the Raptores or Birds of Prey, the Columbæ or Pigeons, the Gallinæ or Pheasants, etc., the Brevipennes or Ostriches, etc., the Limicolæ or Shore Birds, the Herodiones or Herons, etc., the Alectorides or Rails, etc., the Lamellirostres or Ducks, etc., the Steganopodes or Gannets, etc., the Louaipennes or Gulls and Petrels, the Pygopodes or Divers, etc., and the Sphenica or Penguins.



SECTION IV.

THE CLASS OF REPTILIA OR REPTILES.

SUB-SECTION I.

THE REPTILIA CONSIDERED AS A CLASS.

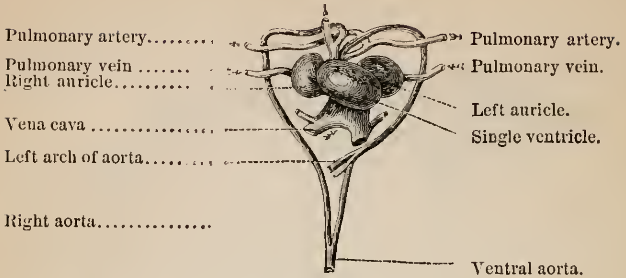
TRUE Reptiles include all cold-blooded oviparous vertebrates which are covered with scales, or with bony plates, or both, and which lay their eggs upon the land, and whose young as soon as hatched closely resemble their parents.

Most kinds of reptiles swallow their prey whole, and the digestion of all is sluggish. Their œsophagus, and muscular stomach, are generally more or less similar to those of Birds.

Their blood has comparatively few globules, and the globules are large and elliptical in form.

The circulatory apparatus varies widely from that of Birds and Mammals; the heart, in most cases, having two

FIG. 248.


Pulmonary artery
Pulmonary vein
Right auricle
Vena cava
Left arch of aorta
Right aorta
Pulmonary artery.
Pulmonary vein.
Left auricle.
Single ventricle.
Ventral aorta.

Reptilian Heart—Turtle.

auricles and only one ventricle. Crocodilians, however, have two auricles and two ventricles.

Therefore the impure or venous blood which comes from the various parts of the body into the right auricle, and the arterial or pure blood which comes from the lungs into the left auricle, are both poured into the one ventricle, and thus mixed together. At each contraction of this ventricle a part of this blood is sent to the lungs to be purified, and the remainder goes into the circulation without having been subjected to the influence of respiration.

Thus the blood of Reptiles is never completely oxygenated; to a certain extent it is always impure, and hence their temperature is correspondingly low, and their habits are generally sluggish. In warm climates, however, some kinds—as Lizards—are very active.

Reptiles breathe by means of lungs; but, as might be inferred from the facts already stated, their respiration is not active; they consume comparatively little oxygen, and can remain alive a long time beneath the surface of the water. The cells of the lungs are larger and less numerous than in the higher animals. Reptiles have no diaphragm, and there is no separation of the cavity of the chest from that of the abdomen.

As in Birds, the Reptiles have the lower jaw connected with the skull by means of a quadrate bone (Fig. 163); and, as in Birds also, the skull is connected with the first vertebra of the neck by means of only one occipital condyle.

The motatory apparatus of Reptiles—that is, the skeleton, muscles, tendons, etc.—corresponds in its plan of structure to that of the higher vertebrates. The skeleton, though apparently so different from that of Mammals and Birds, nevertheless contains the same elements of structure as are found in these two classes. Compare Fig. 249 with Figs. 24 and 162.

As to the nervous system of Reptiles, it may be stated that the brain is small, and without convolutions, and the hemispheres are hollow. In comparison to the brain the spinal cord is large.

The brain of a Sea-Tortoise weighs only $\frac{1}{1856}$ of the entire animal. In several small birds and quadrupeds, the brain exceeds $\frac{1}{30}$ of the weight of the body.

Reptiles continue to live and exhibit movements long after losing the brain, and even after the head is cut off. The muscles preserve their irritability for a considerable time after being severed from the body; and even the heart pulsates for hours after it is removed, nor does its loss prevent the animal from moving about.

The eyes of Reptiles resemble those of Birds. Some have three eyelids; others, as serpents, have none, and hence their fixed and staring look.

The hearing apparatus is far less complete than that of Birds and Mammals. The external ear is wanting; there is no auditory canal; the drum of the ear is on a level with the surface of the head: the tympanic cavity is imperfectly formed; the bones of the ear are in most cases absent; and the cochlea is often only rudimentary.

The organs of smell are but little developed. The tongue is generally thin and dry, though sometimes fleshy. Their sense of touch is feeble.

Including both living and fossil species, the true Reptiles comprise the following groups, which for our present purposes may be regarded as Orders: *

1. CHELONIA or Testudinata, or reptiles with a shell and with a horny beak instead of teeth; as Turtles.
2. DINOSAURIA, huge fossil reptiles with bird-like, and mammalian characteristics; as *Megalosaurus, Hylæosaurus, Iguanodon, Hadrosaurus,* etc.
3. CROCODILIA, large living reptiles, with a cuirass of bony plates, large conical teeth in sockets, vertebræ concave in front, and convex behind; sacrum generally with two vertebræ, and a heart with four cavities; as Crocodiles, Alligators, and the fossil *Telosaurus,* etc.
4. LACERTIA, reptiles with scales, with the teeth not in sockets, and the heart with only three cavities; as Lizards, fossil *Thecodonts,* etc.
5. ENALIOSAURIA, huge fossil saurians furnished with paddles for swimming, with biconcave vertebræ, and with large teeth set in a groove; as the *Ichthyosaurus, Plesiosaurus,* etc. The *Mososaurus* was also an Enaliosaur, but with teeth in sockets, and the body was covered with bony plates.
6. PTEROSAURIA, or fossil reptiles organized for flight; as *Pterodactyls.*

} SAURIA.

7. OPHIDIA, reptiles with no legs, and with no sternum, and no eyelids, and no external ear; as Snakes.

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* The Reptiles are often considered as comprising only three Orders, thus:

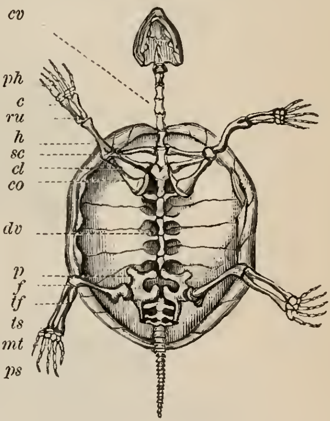
1. CHELONIA or Testudinata.
2. SAURIA (including Dinosauria, Crocodilia, Lacertia, Enaliosauria, and Pterosauria).
3. OPHIDIA.

SUB-SECTION II.

THE ORDER OF CHELONIA OR TESTUDINATA OR TURTLES.

THE Chelonia are reptiles which have a shield or shell upon the back, called the *carapace*, which is connected by bridges to another shield below, called the *plastron*, the whole forming a hard covering for the soft organs of the body. This hard covering is formed of the greatly expanded ribs and sternum, together with ossified skin, and is covered with horny scales. The head, neck, and tail are the only movable parts of the spinal column. The jaws are covered with a horny substance, and are destitute of true teeth; the tongue is short, thick, and covered with fleshy filaments; the nostrils are anterior, and near together; and the eyes have three lids.

FIG. 219.



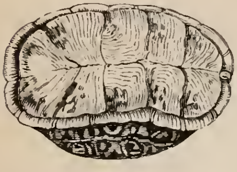
Skeleton of a Turtle, plastron removed.

cv, cervical vertebræ; *ph*, phalanges; *c*, carpus; *ru*, radius and ulna; *h*, humerus; *sc*, scapula; *cl*, clavicle; *co*, coracoid bone; *dv*, dorsal vertebræ; *p*, pelvis; *f*, femur; *tf*, tibia and fibula; *ts*, tarsus; *mt*, metatarsus; *ps*, phalanges.

The Turtles may be divided in two Sub-orders—the AMYDÆ, including all such as have feet instead of paddles, as the Land and Fresh-water Turtles, as the Gophers, Wood Tortoises (Fig. 251), Terrapins, Box Turtles (Fig.

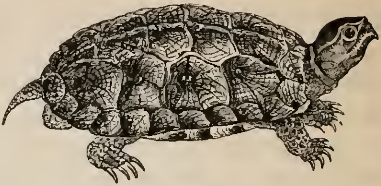
250), Mud Turtles, Snapping Turtles (Fig. 252), etc.; and the CHELONIA or Sea Turtles (Fig. 253), which are furnished with paddles instead of feet.

FIG. 250.



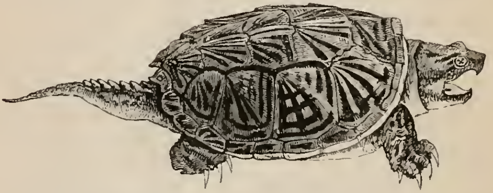
Box Turtle, *Cistudo virginea*, Agassiz.

FIG. 251.



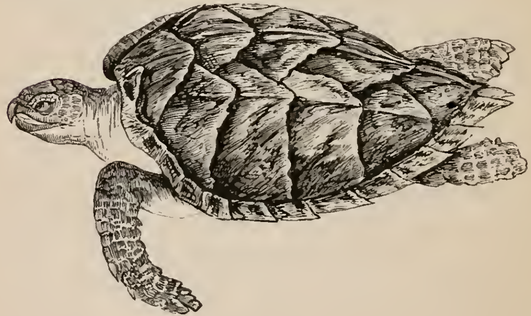
Wood Tortoise, *Glyptemys insculpta*, Agassiz.

FIG. 252.



Snapping Turtle, *Chelydra serpentina*, Schweigger.

FIG. 253.



Hawk-bill Turtle, or Tortoise-shell Turtle, *Eretmochelys imbricata*, Fitz.

The true Land Turtles or Testudinidæ have the shell high and arched, and the legs and feet so lengthened and arranged that the body is raised free from the ground. The Gopher of the Southern States, a turtle a foot and a half in length, is a member of this family. This turtle burrows in the ground, digging holes five or six feet deep.

As additional examples of true land turtles, we may mention the little European Land Tortoise, the only turtle in Europe; and the celebrated Galapago Tortoise, of the Galapagos Islands.

The Terrapins and their allies or Emydoidæ constitute by far the largest family of turtles. Most of the members inhabit bogs, marshes, still streams, and ponds. Some, however, as the Box Turtles, live upon the land; nearly all are perfectly harmless. Their food is both vegetable and animal. Their eggs are more or less elongated, and covered with a shell which is in most cases flexible. The Red-bellied Terrapin, Salt-water Terrapin, Painted Turtle, Speckled Tortoise, Wood Tortoise, etc., are members of this family.

The Mud-turtles or Cinosternoidæ are of smaller size than other turtles, and are relatively long and narrow; and some species emit a musky odor.

The Snapping Turtles or Chelydroidæ have the body high in front, low behind, head large, neck large and long, both jaws strongly hooked, the tail long and powerful, and the sternum small. They are aquatic, but are frequently found upon the land near the water. They are exceedingly powerful. When molested, they raise themselves upon their legs and tail, open wide the mouth, and, forcibly throwing the body forward, snap the jaws upon the assailant with fearful power.

An additional family of fresh-water turtles are those which have soft shells; that is, the shell is not completely ossified, and is therefore more or less flexible. These turtles are called the Trionychidæ, because they have only three nails to each foot. The body is very flat, the neck and head long, and the latter is terminated by a long leathery snout.

The Sea Turtles, as already stated, are furnished with flippers instead of feet. The Green Turtles, the Hawkbill or Tortoise-shell Turtle (Fig. 253), and the Loggerheads are all of enormous size—weighing from two hundred to five hundred pounds or more—and are included in one family, the Chelonioidæ.

There is another family of sea-turtles called the Sphargididæ or Leather-back Turtles, whose general form is something like that of a flattened pyramid, and whose body is covered with a thick coriaceous skin instead of a hard shell. They inhabit the Atlantic and Mediterranean, and are the largest of all turtles, attaining a weight of twelve hundred to two thousand pounds!

Fossil turtles are found in the rocks as old as the Jurassic. One species found in the Tertiary rocks of India had a shell twelve feet in length, and had a total length of twenty feet! According to Cope, a species (*Atlantochelys gigas*) found in Kansas had a breadth, between the tips of its extended flippers, of fifteen feet!

SUB-SECTION III.

THE ORDER OF DINOSAURIA OR DINOSAURS.

UNDER the general name of SAURIA are included all the reptiles except the Turtles and Serpents. It may be stated in general terms, that the Saurians have a long body and a long tail, generally four legs—although in some cases only two, or none—the eyes in most cases furnished with lids, and the ear with an external opening. The Saurians as here defined include the huge fossil Dinosaurs, the Crocodiles, etc., the Lizards, the fossil Ichthyosaurs, etc., the Pterodactyls, etc. The name Sauria comes from the Greek *sauros*, a lizard.

But the differences exhibited by these various forms of saurians lead zoölogists to recognize them as representatives of distinct orders; and they are accordingly so treated in this book.

The Dinosaurs are an order of reptiles which we know only by their fossil remains. They are of gigantic size, and they combine in their structure reptilian, bird-like, and mammalian characteristics. The name is derived from the Greek *deinos*, terrible, and *sauros*, a lizard. Their cervical vertebræ are convex before and concave behind, as in mammals; their sacrum consists of four or five vertebræ, as in mammals; the long bones have a medullary cavity; and the hind feet are more or less bird-like. And these animals often walked on their hind feet, as if bipeds.

To this order belong the Iguanodon, an herbivorous dinosaur of the Jurassic period, an animal of vast bulk, and having a length of twenty to forty feet or more. Here also belong the *Hadrosaurus*, *Hylæsaurus*, and the *Megalosaurus;* the last a gigantic carnivorous Jurassic reptile more bulky than an elephant, and thirty feet in length.

Many of the bird-like tracks of the Connecticut valley are regarded as those of huge dinosaurs. These tracks occur on the successive layers of sandstone of Triassic or Jurassic age; and they are found at various places, from the northern portion of Massachusetts to Long Island Sound.

SUB-SECTION IV.

THE ORDER OF CROCODILIA OR CROCODILIANS.

THE Crocodilians—often called the Loricata—are saurians which have the body covered with horny scales formed from the outside skin, and with bony plates formed in the true skin or derm. They are found only in warm climates, and include the Crocodiles of the Nile, the Gavials of the Ganges, the Alligators of America, the fossil *Teleosaurs*, etc.

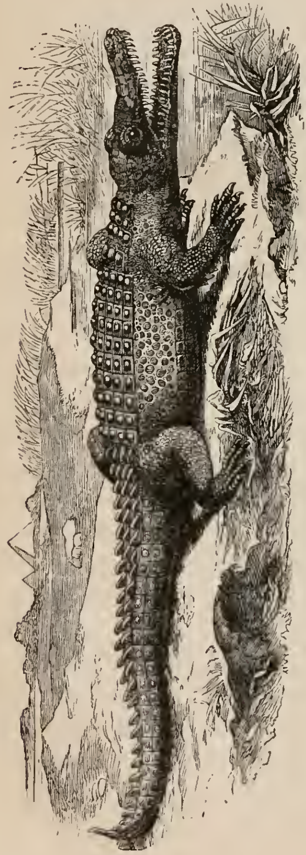


FIG. 254.

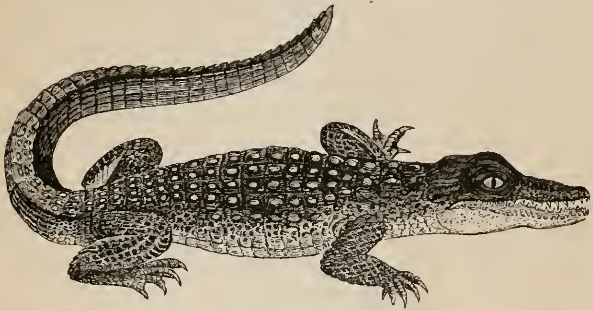
Crocodile of the Nile.

The Crocodilians have four cavities in the heart, as in warm-blooded animals. Their dorsal vertebræ are concave in front and convex behind. Their sacrum is, in most species, composed of only two vertebræ. They have four toes before and five behind. The bones of their skull and face are very firmly united together. Their teeth are set in sockets in a single row, and are in a constant process of renewal as fast as shed. Their tongue is fleshy and fixed to the bottom of the mouth.

Their eyes have movable eyelids, their ears movable earlids, and their nostrils are in the extremity of the snout and capable of being closed by a valve.

The tail of the Crocodilians is exceedingly powerful, and with it they strike down and sweep into the water large animals upon which they would prey. The Crocodile immediately seizes its victim and drags it beneath the surface of the water to drown it. By a peculiar arrangement the Crocodile can instantly close the entrance to its throat, so as to prevent the ingress of water, and thus, by bringing from time to time the extremity of its snout above the surface, it can with impunity maintain its grip upon the prey and keep it under water.

Fig. 255.



Alligator, *Alligator Mississippiensis*, Gray.

The true Crocodiles attain the length of thirty feet; the Alligators fifteen feet or more.

Crocodiles have the long "canine" teeth so arranged as to fit into holes in the upper jaw, the hind feet webbed nearly to the toes, and a ridge of projecting scales down the outer border of their hind legs.

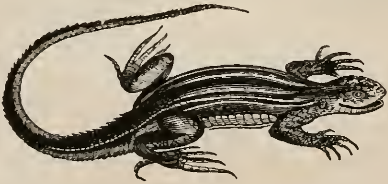
Alligàtors have the "canine" teeth arranged to fit into a pit in the upper jaw, and they have no ridge of projecting scales on the outer border of their hind legs, and their hind feet are not so completely webbed as those of the Crocodiles.

SUB-SECTION V.

THE ORDER OF LACERTIA OR LIZARDS.

THE Lacertias are saurian reptiles whose bodies are covered with scales, and whose vertebræ are concave before and convex behind, or concave on both faces. They have only two, or at most three, vertebræ in their sacrum. None of the living species have teeth set in sockets. The heart has two auricles and one ventricle; the ventricle is, however, partially divided by a partition into a right and left portion.

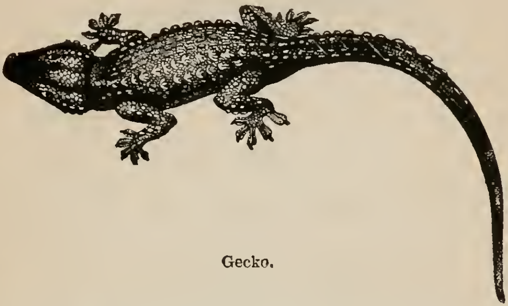
FIG. 256.



Striped Lizard, *Ameiva sex-lineata*, Cuvier.

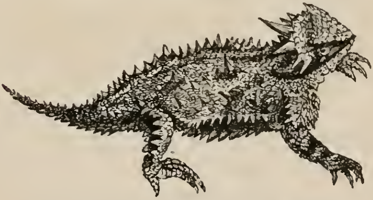
Some of the members of this order, as the Green Lizard and Striped Lizard of our Southern States, are only six to ten inches in length. Others, like the Monitor of the Nile and the Iguana of South America, are from four to six feet in length. Some, like the Dragons (*Draco*) of the East Indies, have their ribs extended outwards and supporting a fold of skin, and thus forming a sort of wing which acts as a parachute in sustaining them as they leap from one tree to another, and thus making them appear as if flying. Others, like the Geckos (Fig. 257) of the tropical regions, have toes provided with a flattened disk which enables them to crawl up walls and even along the ceilings with the back downwards. Some, like the "Horned Toads" of Western North America, are armed with tubercles and spines. Others, as the Chameleons of the Old World, have the tail prehensile, the tongue fleshy and extensible, the eyes large and covered with skin, except a small hole opposite the pupil, and possessing the faculty of moving independently of each other!

Fig. 257.



Gecko.

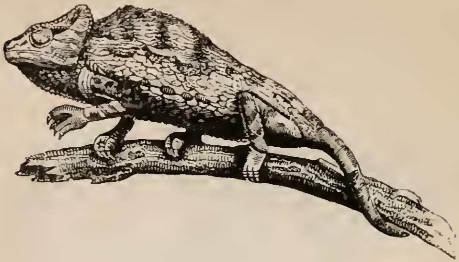
Fig. 258.



Horned Toad, *Phrynosoma cornuta*, Gray.

Other lacertians still, as the Glass-snakes of the Mississippi valley, are snake-like in general appearance, having no external locomotive members. They received their

FIG. 259.



Chameleon.

peculiar name from their form, and from the fact that the vertebræ of the tail are so slightly adherent that the tail is easily broken. And lastly, there are other lacertians, like the Slow-worms of Europe, and the Double-walkers of South America—the latter of which can move forwards or backwards with equal facility—that are so unlike the typical lizards that naturalists hesitate whether or not they ought to be retained in the order.

Geologists recognize certain fossil lacertians as among the earliest of true reptiles, and they describe them under the name of *Thecodonts* (from the Greek *theke*, a sheath, *odous*, a tooth), etc. These reptiles have small scales and biconcave vertebræ similar to those of fishes, but they are allied to the Crocodilians in having their teeth in sockets. They made their appearance in the Carboniferous period.

SUB-SECTION VI.

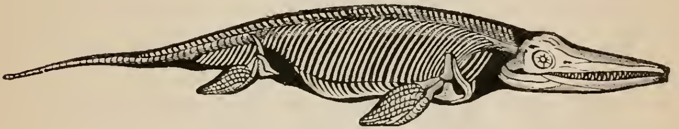
THE ORDER OF ENALIOSAURIA OR SEA-SAURIANS.

UNDER this head we may include a host of huge extinct saurians which inhabited the seas and estuaries in the old Jurassic and Cretaceous times, and whose structure is so wonderful, and whose size is so gigantic, that we might well doubt they had ever lived, were it not that their fossil remains exist in the greatest abundance and in wonderful perfection.

The Enaliosaurs are furnished with paddles for swimming, and, like fishes, their vertebræ are concave at each end; and, excepting the *Mosasaurs*, which have their teeth in sockets, they have their large teeth set in a groove.

The *Ichthyosaurus* is a genus of the Sea-saurians of the Jurassic period, which are from ten to forty feet in length, with the bony cavity for the eye nearly a foot in diameter, and with jaws in some species nearly six feet long, and armed with two hundred stout conical teeth!

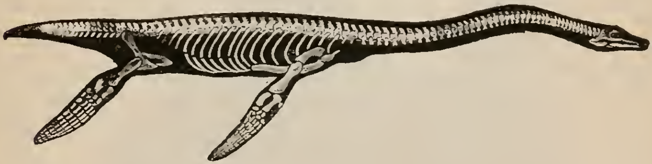
FIG. 260.



Ichthyosaurus.

The *Plesiosaurus* is a genus of sea-saurians, ten to thirty feet in length, which are characterized by a long snake-like neck—having from twenty to forty vertebræ—a small head, and short body.

FIG. 261.



Plesiosaurus.

The *Discosaurus* (*Elasmosaurus platyurus*, Cope) had a total length of fifty feet, and its neck, with over sixty vertebræ, was twenty-five feet long!

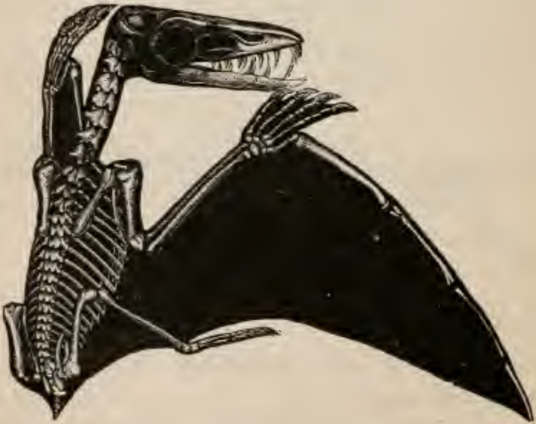
But, if possible, still more wonderful sea-saurians are included in the genus *Mosasaurus*. These Sea-saurians, unlike those previously mentioned, have the teeth in sockets, and their body covered with bony plates. The remains of more than forty species have been found in the Cretaceous rocks of New Jersey, the Gulf States, and Kansas. They were exceedingly snake-like in their appearance, and some of them were at least seventy-five feet long! They were the "Sea-Serpents" of the old Cretaceous oceans.

SUB-SECTION VII.

THE ORDER OF PTEROSAURIA OR FLYING SAURIANS.

ALL the members of this order are also extinct. The name Pterosaurus comes from the Greek *pteron*, a wing,

FIG. 262.



Pterodactyl.

and *saurus*, a lizard, and briefly describes these strange forms. The body resembles that of an ordinary mammal, the jaws and teeth those of a crocodile; and the wings remind us of those of a bat. The fifth or little finger is exceedingly elongated, thus affording a support for a membrane, which, with the arm, made a wing for flying. The principal genus is *Pterodactylus* (Fig. 262), and it includes species of various sizes, from those having a spread of three feet, like some of those found in the Old World, to some of the gigantic species (*Pterodactylus ingens*, Marsh) in the Cretaceous rocks of the central portion of the United States, which have a spread of twenty-five feet!

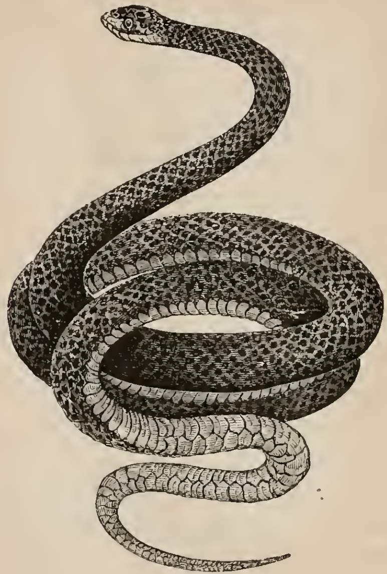
SUB-SECTION VIII.

THE ORDER OF OPHIDIA OR SERPENTS.

SERPENTS are scaly reptiles which are exceedingly elongated and without feet, and whose skull and jaws, vertebræ and ribs, make up the whole skeleton—both sternum and sacrum being wanting. A pair of slender bones, however, often supporting a second bone armed with a claw, are found suspended in the flesh near the hind part of the body, in some species; these are regarded as the rudiments of hind limbs.

The vertebræ in serpents are exceedingly numerous, and articulate with each other not only by a cup and ball on the central portion of the vertebræ—that is, on the centrum—but also by eight joints in addition to these, which interlock by parts reciprocally receiving and entering into one another; and thus the vertebral column is very strong, while at the same time it has great freedom of motion. Moreover, as the danger is greatest of being crushed by blows from above, all the joints are made so that they can best resist vertical pressure. And it may here be added that, in accordance with this structure, there is little or no natural upward and downward undulation of the body; but all the undulations are from side to side. The ribs commence at the third vertebra from the head, and are very numerous. They are movable, and aid greatly in locomotion.

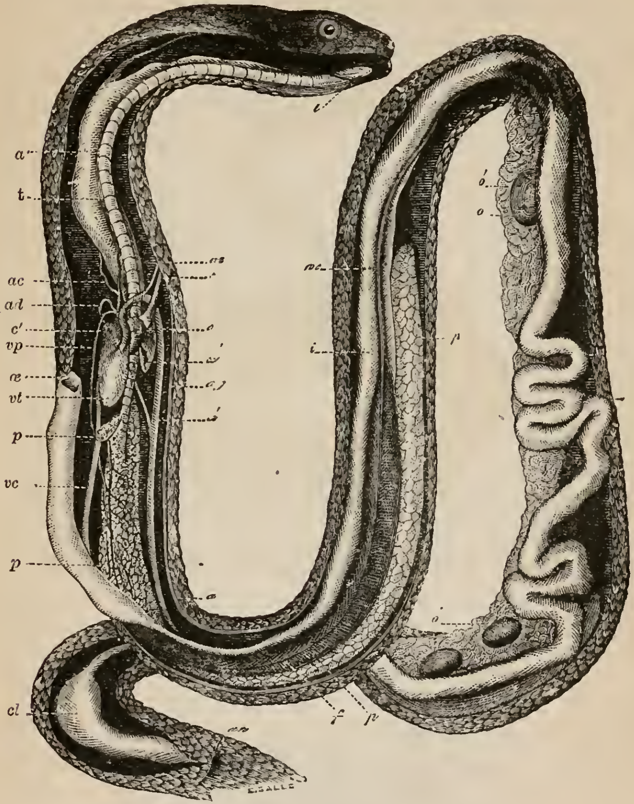
Fig. 263.



Black Snake, *Bascanion constrictor*, Baird and Girard.

The bones of the jaws and mouth, which in the higher animals are more or less firmly united, are connected in serpents by extensible ligaments only—an arrangement by which the mouth may be distended so as to receive an object of much greater diameter than the serpent itself. Their teeth are pointed, smooth, and arched towards the throat.

FIG. 264.



Showing the internal structure of a Serpent.

l, tongue and glottis ; *œ*, gullet cut across at *œ'* to show the heart, etc. ; *i*, the stomach ; *i'*, intestine ; *cl*, cloaca; *an*, anus ; *f*, liver ; *o*, ovarium ; *o'*, ova ; *t*, windpipe ; *p*, principal lung ; *p'*, little lung ; *vt*, ventricle ; *c*, left auricle ; *c'*, right auricle; *ag*, left aorta; *ad*, right aorta; *a'*, ventral aorta ; *ac*, carotid arteries ; *v*, superior cava ; *vc*, inferior cava; *vp*, pulmonary vein; *a*, alimentary canal or gullet, upper portion.

The tongue of serpents is long, slender, bifid, extensible, and retractile within a sheath; the eyes are without movable lids; trachea very long; lung single, and extending nearly the whole length of the body.

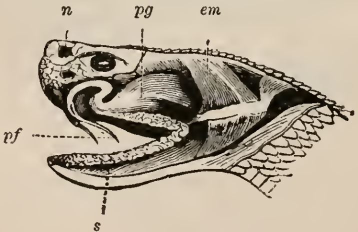
Serpents cast their skins at least once a year. They lay eggs with a flexible shell; some of them, however, are ovo-viviparous; that is, the eggs are hatched while still in the body of the parent. This is especially true of venomous snakes.

The Boa-Constrictor and Anaconda of South America, the Pythons of Africa and the East Indies, constitute the family of Boidæ, huge serpents in some cases attaining the length of thirty or forty feet, and capable of swallowing dogs, sheep, and deer, after having crushed them in their powerful folds. They have spur-like appendages as rudiments of hind limbs.

All of our most common species, as the Striped Snakes, Water Snakes, Black Snakes, and a long list of allied genera, belong to the family of Colubridæ. They have no rudiments of hind limbs.

Rattlesnakes or Crotalidæ and their allies are serpents whose upper jaw contains but few teeth, but is armed with sharp-pointed, movable poison-fangs. These fangs

FIG. 265.



Head of a Rattlesnake.

em, elevator muscles; *pg*, poison gland; *n*, nostril, beneath which is a little cavity or pit; *pf*, poison fangs; *s*, salivary glands.

are concealed in a fold of the gum, or raised, at the will of the animal. They connect with a gland situated near the eye, which furnishes the fluid poison. When the snake bites, the fangs are raised, and the pressure of the temporal muscles upon the gland forces the poison along the fang into the wound. These animals have a deep pit between the eye and the nostril, and the rattlesnakes proper have the tail furnished with a rattle, with which they make a peculiar noise when they apprehend danger, or perhaps when they would call their mate.

The Crotalidæ include not only the Rattlesnakes proper, but also the Copperhead, Moccasin, etc., snakes even more dangerous than the first named, as they strike without warning.

Some kinds of poisonous snakes, like the Harlequins or Elapidæ of the warm parts of the United States, have the fangs permanently erect.

In India and Africa there are poisonous snakes known as Vipers, which can raise up and draw forward the anterior ribs so as to dilate the forward part of the body into a more or less broad disk. The Spectacled Viper or Cobra of India is one of these vipers which has a black line resembling in outline a pair of spectacles traced on the widened portion of its disk. This is the snake whose fangs the jugglers of India extract, and then train it to dance! The Asp of Egypt is a viper not less noted. The ancient Egyptians made it the emblem of the protecting divinity of the world, and sculptured it on the sides of a globe upon the gates of their temples. By pressing this snake on the nape, the jugglers of Egypt threw it into a stiffened immovable condition, which they called turning it into a rod. It is probably the Asp of Egypt, and Asp of Cleopatra.

Snakes which have the posterior parts of the body and tail much compressed, and raised vertically, thus adapting them for swimming, are called Sea-snakes or Hydrophidæ. They are of small size, and inhabit both the salt and fresh waters in warm climates, and are very venomous.

Principal Topics Considered in Chapter II., Section IV.

SUB-SECTION I.

Reptiles considered as a Class.——How they eat.——Blood.——Circulatory apparatus.——Respiration.——Skeleton, etc.——Nervous system.——Eyes.——Hearing apparatus.——Smell.——Touch.——Classification of Reptiles.

SUB-SECTION II.

The Order of Chelonia.——Land and Fresh-water Turtles.——Sea Turtles.——Fossil Turtles.

SUB-SECTION III.

The Order of Dinosauria.——Sauria in general.——Structure and size of Dinosaurs.——The Geological period to which they belong.

SUB-SECTION IV.

The Order of Crocodilia.——Living examples.——Where found.——Crocodilians more fully described.——Crocodiles and Alligators compared.

SUB-SECTION V.

The Order of Lacertia.——Living examples briefly noticed.——Fossil Lacertians or Thecodonts, and when they made their appearance.

SUB-SECTION VI.

The Order of Enaliosauria.——Ichthyosaurus.——Plesiosaurus.——Discosaurus.——Mosasaurus.

SUB-SECTION VII.

The Order of Pterosauria.——Structure and size of Pterosaurs.——Where found.

SUB-SECTION VIII.

The Order of Ophidia.——Serpents more fully described.——Boas, Anacondas, Pythons.——Striped Snakes, etc.——Rattlesnakes, etc.——Harlequins.——Vipers.——Sea-snakes.

SECTION V.

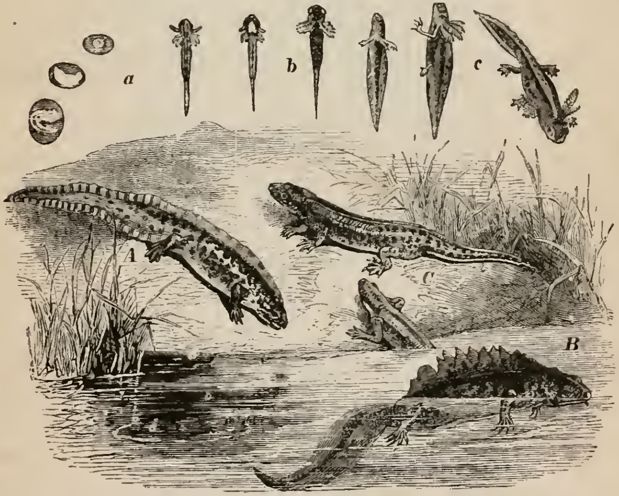
THE CLASS OF BATRACHIA OR BATRACHIANS.

SUB-SECTION I.

THE BATRACHIA CONSIDERED AS A CLASS.

THE Batrachia, often called Amphibia, are cold-blooded oviparous reptiles which, with few exceptions, are destitute of scales, and which, in most cases, lay their eggs in the water, or in damp places, and whose young hatch in a very immature condition, and pass through a series of

FIG. 266.



Various phases in the life of a Batrachian, from the egg to the adult state—Triton or Newt.

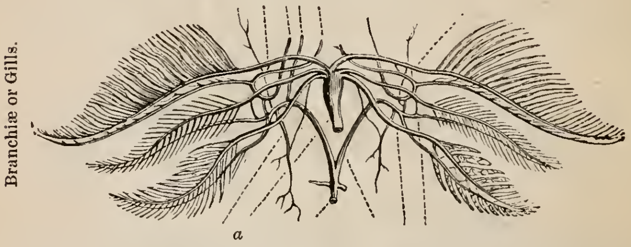
changes before they acquire the form of the parents. The name is from the Greek *batrachos*, a frog; and the group includes Frogs, Toads, Salamanders, Tritons, etc.

Some kinds, as Tree-toads, lay their eggs on trees in places overhanging water, and the young, as soon as hatched, drop into the water.

Pipa or Surinam Toad, of South America, lays its eggs in the water, after which they are collected by the male, and placed on the back of the female, the skin enlarging in such a manner as to inclose the eggs in cells; here the development goes on till the young come forth as perfectly formed toads.

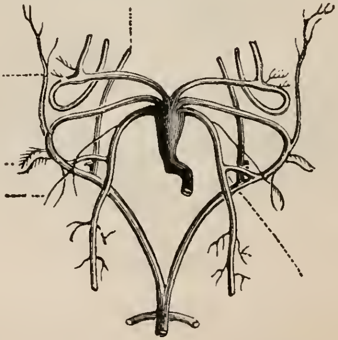
A small frog of Venezuela has a pouch upon the back in which the eggs are carried and hatched.

Fig. 267.



Blood-vessels of a Batrachian—Frog—in the Tadpole state. *a*, artery arising from the single ventricle and dividing into six branches, which go to the three pairs of branchiæ.

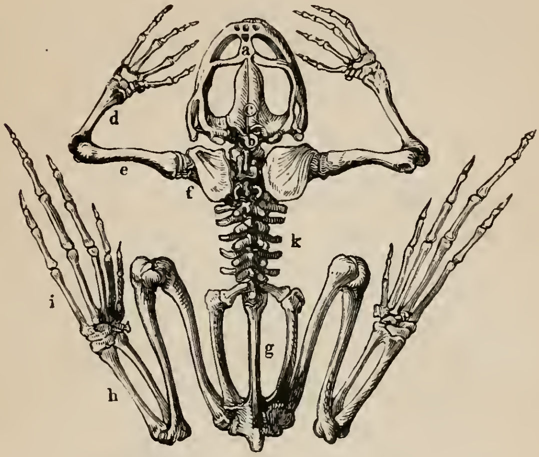
Fig. 268.



The same as Fig. 267, in the adult state.

Batrachians have the skull very flat and usually broad, and of a very open structure; two occipital condyles for the articulation of the head with the body; and the ribs very short or wanting.

FIG. 269.



Skeleton of a Batrachian—Frog.

The young batrachians breathe by means of gills, and, in most cases, live in the water, being thus more or less fish-like, and are called tadpoles. But in the adult state, with few exceptions, the gills disappear and then these animals breathe by means of lungs. Their lungs are two and equal, and their heart has never more than three cavities—two auricles and one ventricle.

The Batrachia comprise the following Orders:

1. ANOURA or Tailless Batrachians, as Frogs and Toads.
2. URODELA or Tailed Batrachians, as Salamanders, Tritons, Sirens, etc.
3. APODA or Footless Batrachians, as snake-like batrachians or Cæcilians.

Besides these there is an extinct group, known only by the fossil remains of its representatives, and this is added as an additional order, thus—

4. LABYRINTHODONTA or Labyrinthodonts, so called from the internal structure of their teeth.

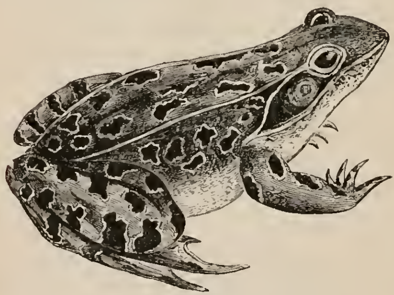
SUB-SECTION II.

THE ORDER OF ANOURA OR TAILLESS BATRACHIANS.

THIS order includes the Frogs and Toads, and is sometimes called the order of Batrachoids. The name Anoura comes from the Greek *an*, privative, and *oura*, a tail.

The Anourans have the body short and thick, and covered with a skin which does not adhere to the muscles, but covers them somewhat loosely as a sack. Their tongue is long and fixed to the front of the jaw, and its tip is turned backward in the mouth, whence it can be instantly darted forth; and it is in this way that these animals so quickly snap up living insects which constitute their food.

FIG. 270.



Leopard Frog, *Rana halecina*, Kalm.

The young are tadpoles, which have a large head, short, thick body, and a long compressed tail, and which feed upon vegetable food. As they grow older, the extremities appear, the tail is gradually absorbed, the gills are superseded by lungs, which heretofore were undeveloped, and the animal becomes air-breathing and carnivorous.

Fig. 271.

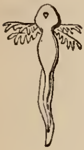


Fig. 272.

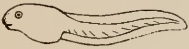


Fig. 273.

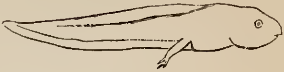


Fig. 274.

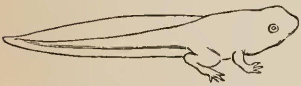


Fig. 275.

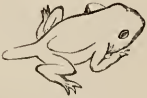
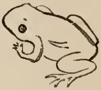


Fig. 276.

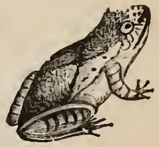


Changes in the form of Frogs and Toads from the time of hatching.

The Bull-frog, Leopard-frog (Fig. 270), Pickerel-frog, Wood-frog, etc., are prominent representatives of the true frog family or Ranidæ, which have the toes free, and never dilated into a disk.

The Tree-frogs or "Tree-toads" or Hyloidæ have the extremities of the toes enlarged into a disk, by means of which they sustain themselves on the trunks and branches of trees. Those called Cricket-frogs (*Hylodes*) are very small, and are found on plants near the water, where their shrill piping note may be heard all the night, in summer.

Fig. 277.



Cricket-frog. *Hylodes Pickeringii*, Holbrook.

The Toads or Bufonidæ have the body warty above and granulated beneath; and the upper jaw and palate, in most cases, destitute of teeth. They are mainly nocturnal in their habits. They live upon the land, except in the

Spring, when they live in ponds and pools, where they go to lay their eggs.

The eggs of Toads are laid in long glairy "strings;" those of Frogs in large glairy masses.

SUB-SECTION III.

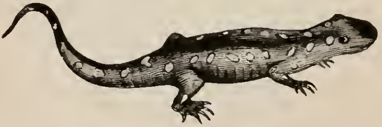
THE ORDER OF URODELA OR SALAMANDERS, ETC.

BATRACHIANS of this order have a tail at all periods of their life, and in most species four feet. The name comes from the Greek *oura*, a tail, and *delos*, manifest.

The body of the Urodelans is long, and more or less lizard-like in general outline, and covered with a skin which is adherent to the muscles. They have no sternum, and the ribs are rudimentary; and the fore feet of the young are developed before the hind ones (see Fig. 266).

In their adult state, most Salamanders proper live upon the land, going into the water only at the season in which they lay their eggs. Some kinds are terrestrial throughout life, laying their eggs under stones and old logs, in damp places.

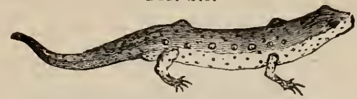
FIG. 278.



Salamander, *Amblystoma punctatum*, Baird.

The Tritons are salamanders which have the tail compressed, and which are aquatic; yet, as they respire by means of lungs, they come to the surface of the water from time to time for atmospheric air. They have the most wonderful power to reproduce mutilated or lost parts. The limbs may be removed, and in less than a year they will grow again; and the newly-formed limbs may in turn be amputated, and will in turn be replaced by others!

FIG. 279.



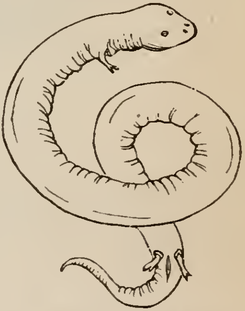
Triton or Water-Newt, *Diemictylus viridescens*, Rafinesque.

Both Salamanders and Tritons belong to one family, the Salamandridæ.

Some kinds of salamandrine batrachians, as the Congo Snakes of the South, and other similar species, are said to be destitute of gills at all periods of their existence, breathing by means of exposed spiracles or branchial orifices at the sides of the neck. They live in the water, and belong to the family of Amphiumidæ.

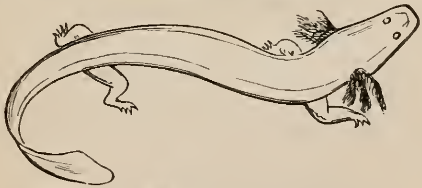
The Congo Snakes have an eel-shaped body, four imperfectly developed legs, and a single spiracle on each side of the neck.

FIG. 280.



"Congo Snake," *Amphiuma means*, Linn.

FIG. 281.

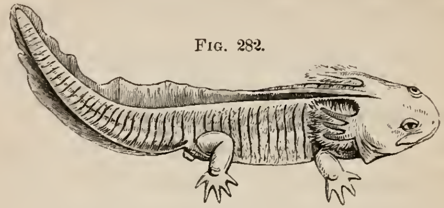


Mud-Puppy, *Menobranchus lateralis*, Say.

Other kinds of salamandrine batrachians, as the Sirens, Menobranchus, Siredons, Proteus, etc., have permanent external branchiæ that occur in tufts, covering the branchial orifices. They also have lungs like others of their class, and are thus true amphibians. It will be observed that, *even in their adult state, these animals represent the embryonic forms of the higher batrachians.* They are one to two feet in length in most cases, and constitute the family of Sirenidæ.

The Siredons or Axolotls of Mexico and of Western North America are from six to ten inches long, and every way similar in form to young aquatic salamanders. They live mainly in the water. *Proteus*, represented by a species a foot long in the waters of Adelsberg Cave, Carniola, is a related genus.

FIG. 282.

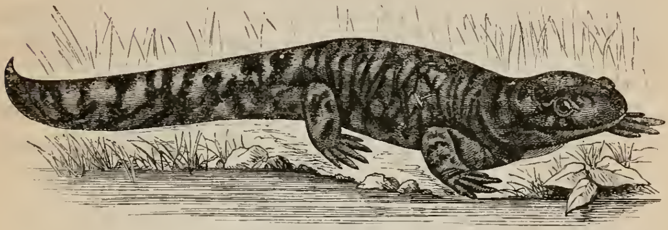


Siredon, *Siredon lichenoides*, Baird.

The Siredons have always been regarded with great interest, because they represent, even in their adult form, one of the transient stages of the higher urodelan-batrachians. But, of late, they have become still more interesting, from the fact that Prof. O. C. Marsh (see Am. Jour. of Sci. and Arts, Nov., 1868) has discovered that, under some circumstances, the *Siredon lichenoides*, Baird, wholly abandons the *Siredon* form, and becomes a genuine *Amblystoma mavortium*, Baird. Fig. 283 is a copy of Marsh's figure of the Amblystoma after it had passed through its entire transformation.

Of the Siredons which the Professor was keeping in vessels of water, he found that "two specimens, most favored in regard to light and warmth, passed apparently through the entire transformation in about twenty days. Those that commenced at the same time, but were less favorably situated, required at least twice that time for its completion."

FIG. 283.



Amblystoma mavortium, Baird.

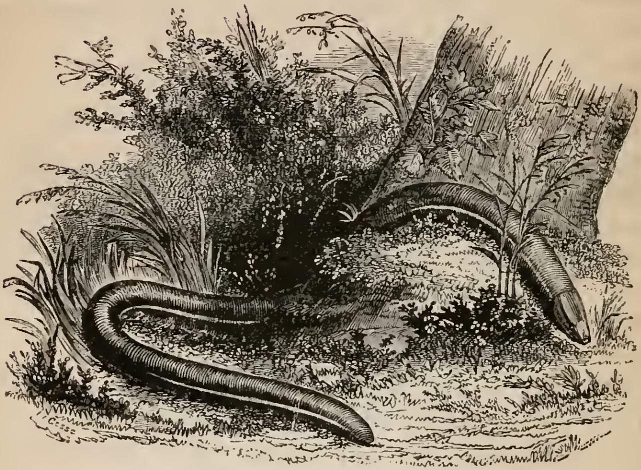
Siredons are abundant in Lake Como, a small sheet of water near the Union Pacific Railroad, in Wyoming.

SUB-SECTION IV.

THE ORDER OF APODA OR SNAKE-LIKE BATRACHIANS.

THE batrachians of this order are destitute of limbs, and move like serpents. They are known under the name of Blind-worms or Cæcilians, a name derived from the Latin word *cæcus*, meaning blind, and given to these animals on account of their exceedingly minute eyes; so minute that some of the species seem entirely wanting in these organs. The Cæcilians vary from one to three feet

FIG. 284.



Blind-worm, *Cæcilia.*

in length, and are found in the marshes of the tropical regions. Contrary to what is true of batrachians generally, these animals develop dermal scales.

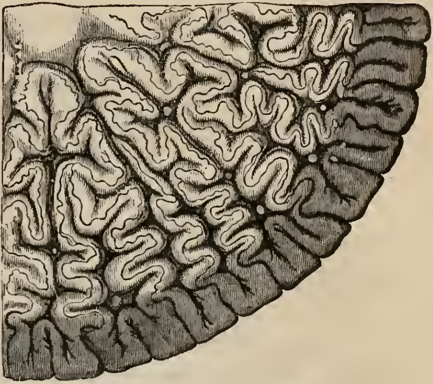
SUB-SECTION V.

THE ORDER OF LABYRINTHODONTA OR LABYRINTHODONTS.

THE Labyrinthodonta are scale-covered batrachians which, as already stated, are wholly extinct. They are known only by their fossil remains. They get their name from the labyrinthine arrangement of the cement and dentine of the teeth, as seen in Fig. 285—a kind of structure which is found in the teeth of Ganoid fishes. These batrachians were more or less frog-like in their general outline.

Labyrinthodonts are found in the Carboniferous and Triassic rocks, and some of the species are of gigantic size, having in some cases a skull three or four feet long, and a body vastly more bulky, probably, than that of an ox. Representatives of this order have left their foot-prints in the Connecticut river sand-stone, each foot-print being twenty inches long.

Fig. 285.



Magnified Cross-section of about one quarter of a tooth of a Labyrinthodont.

Principal Topics Considered in Chapter II., Section V.

SUB-SECTION I.

The Batrachia considered as a Class.——Origin of the name.——Where they lay their eggs.——The young.——Skull.——Breathing apparatus.——Heart.——Classification.

SUB-SECTION II.

The Order of Anoura.——Origin of the name.——Form.——Skin.——How they secure food.——The young.——True Frogs.——"Tree-toads."——Toads.——Eggs of Toads.——Eggs of Frogs.

SUB-SECTION III.

The Order of Urodela.——Origin of the name.——Form and Structure.——Salamanders proper.——Tritons.——Amphiumidæ or "Congo Snakes."——Sirenidæ or Siredons, etc.

SUB-SECTION IV.

The Order of Apoda.——Form.——Size.——Where found.——Eyes.——Scales.

SUB-SECTION V.

The Order of Labyrinthodonta.——Why so named.——Where found.——Size.

SECTION VI.

THE CLASS OF PISCES OR FISHES.

SUB-SECTION I.

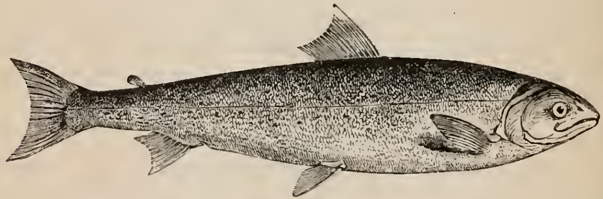
THE FISHES CONSIDERED AS A CLASS.

FISHES are cold-blooded vertebrates which live exclusively in the water, and respire by means of gills instead of lungs.*

The limbs corresponding to the locomotive members of the higher vertebrates are comparatively little developed, and are called fins.

Those fins which correspond to the anterior locomotive members of higher vertebrates are called *pectorals*, and those which correspond to the posterior, *ventrals*. Besides the pectorals and ventrals, there are other fins which are vertical. Those upon the back are called *dorsal*, those beneath the tail *anal*, and the fin at the end of the tail *caudal*.

FIG. 286.



p, pectorals; *v*, ventrals; *d*, dorsal; *a*, anal; *c*, caudal.

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* The Climbing Perch, of the East Indies, sometimes leaves the water, and moves for considerable distances upon the land, and, in some cases, even ascends the trunks of trees! This fish has an apparatus under the gill-covers by means of which water is retained and given up to the gills drop by drop.

Fishes feed mainly upon smaller members of their own class, and upon other smaller animals. Some kinds, however—as the Lancet-fishes of the tropical seas—are vegetable feeders. Most kinds swallow their prey whole. Some, which feed on shell-fish, crush their food by means of the powerful crushing and grinding teeth in the gullet. Digestion is performed very rapidly. The blood is red, and the globules are large and elliptic.

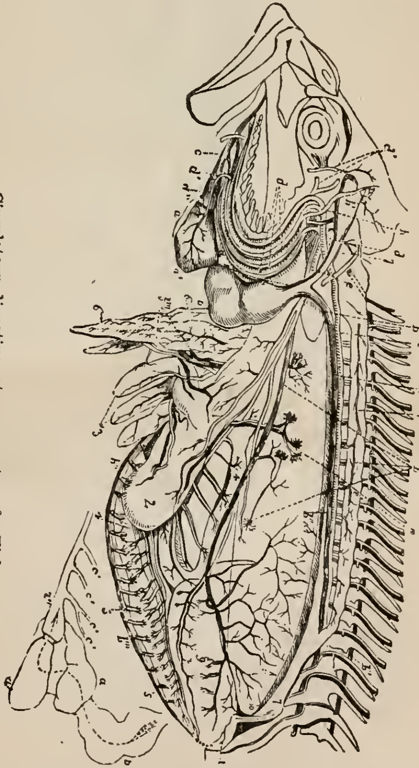


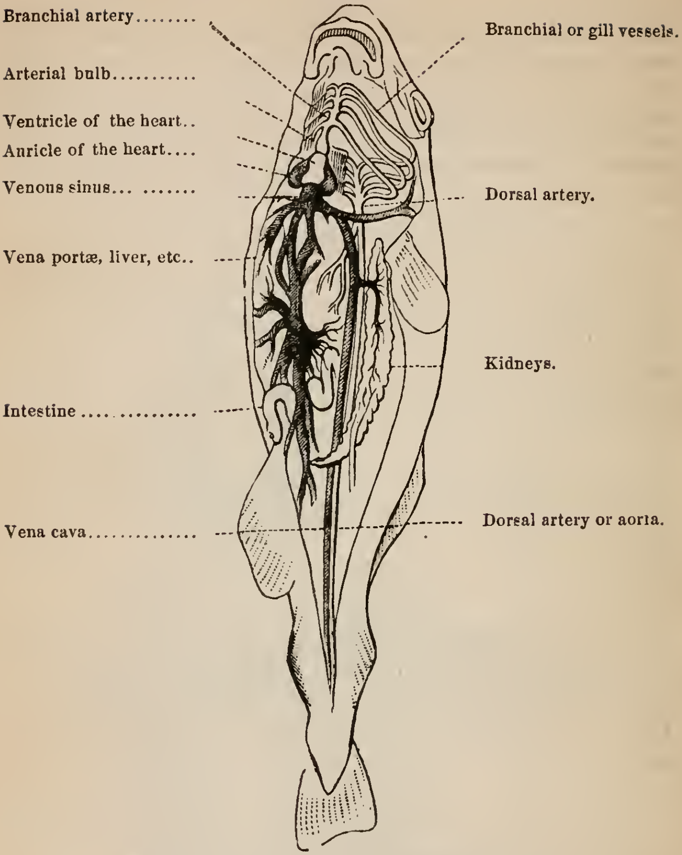
FIG. 287.

Circulatory, digestive, etc., apparatus of a Fish.

a, auricle; *a′*, ventricle; *a″*, dilatation of the branchial trunk *c*; *b*, sinus venosus; *b′*, trunk and sinus of the cephalic veins; *b″ b″*, venous trunks from the locomotive organs; *b‴*, venous trunks from digestive organs, etc.; *c*, branchial artery; *d*, branchial veins; *d′ d′* arteries which go to the head and heart: *e*, branch of the aorta; *e′*, spinal trunk, 1, œsophagus; 2, stomach; 3, pancreatic cæca; 4, small intestine; 5, large intestine; 6, liver; 7, renal organs; 8, urinary organs; 9, organs of generation; 10, swimming bladder.

The heart of fishes contains only two cavities, corre-

FIG. 288.


Branchial artery........
Arterial bulb...........
Ventricle of the heart..
Auricle of the heart....
Venous sinus... ....
Vena portæ, liver, etc..
Intestine ....
Vena cava..............
Branchial or gill vessels.
Dorsal artery.
Kidneys.
Dorsal artery or aorta.

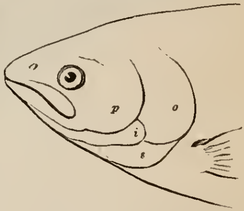
Another view of the Circulatory apparatus of a Fish.

sponding to the right auricle and right ventricle of warm-blooded vertebrates; and the blood passes only once through the heart instead of twice, as in Birds and Mammals.

The auricle receives only the venous blood returned to it from all parts of the body. From the auricle this blood passes into the ventricle; from the latter cavity it passes to the gills through a single artery which has at its origin a contractile bulb. Having been purified in the gills, the blood is poured into an arterial trunk, situated under the spine, whence it is distributed to every part of the body, and in due time is returned by the veins to the auricle of the heart. Notwithstanding that the circulation is single, that is, the blood passes through the heart only once before passing through the body, it is *complete*, since none of the blood circulates through the body till after it has been purified in the gills.

Respiration, as already indicated, is performed by means of gills. These are delicate fringes or laminæ, supported on bony arches. In most species the gills are covered by means of a sort of lid composed of three pieces, plainly or obscurely indicated, and called the *operculum*, *suboperculum*, and *interoperculum*. This lid or gill-cover plays on one called the *preoperculum*. In some groups, however, the gill-covers are wanting.

FIG. 289.



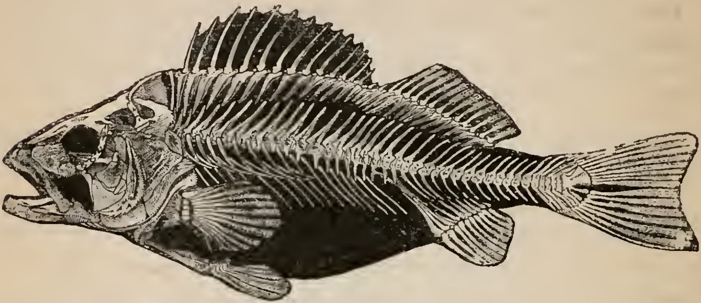
p, preoperculum; *o*, operculum; *s*, suboperculum; *i*, interoperculum.

In the process of breathing, the mouth and gill-covers open alternately, and the water which enters the mouth passes through the gills and escapes at the gill-openings. Thus the gills are constantly bathed with water, and the oxygen needed is secured from the air which is mingled with the water.

Fishes, in most cases, are furnished with a membranous sac filled with air, and called the swimming-bladder. This organ is probably a rudimentary lung, but its true function is not known; although some believe that by it Fishes have the power of varying their specific gravity, and thus more easily rising and sinking in the water. Others believe that it aids in hearing.

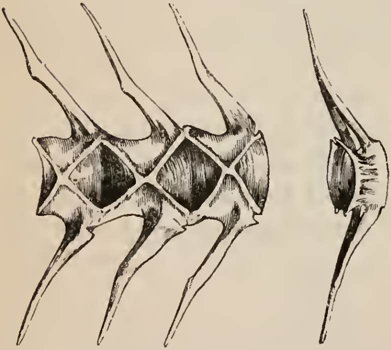
The spinal column of Fishes is made up of vertebræ which are concave at each end, and the cavities which thus occur between the vertebræ are filled by a soft membranous and gelatinous substance, which extends from one cavity to another, through a hole with which each vertebra is pierced. The spinal column bends with perfect freedom laterally, but not in a vertical direction; and it

Fig. 290.



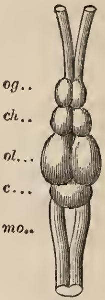
Skeleton of a Fish—Perch.

Fig. 291.



Four vertebræ of a Fish; on three a portion of the side is cut away to show the cavity between the vertebræ.

Fig. 292.



Brain of a Cod.
og, olfactory ganglia; *ch*, cerebral hemispheres; *ol*, optic lobes; *c*, cerebellum; *mo*, medulla oblongata.

is chiefly by the lateral motions of the tail and body that Fishes are propelled; although some Fishes — as Pipefishes (Fig. 311) — swim principally by the undulation of the dorsal fin. The fins are employed mainly in balancing and directing.

The muscular system is generally highly developed. The flesh, excepting certain muscles which are deep red, is paler than that of Birds and Mammals, and in some cases is pure white. One large and complicated muscle on each side, and filling up the space from the head to the tail, furnishes the principal motive power.

The brain is exceedingly small, and seldom fills the cavity in which it is situated (Fig. 292).

With few exceptions, the eye of Fishes has no motion; and the iris neither contracts nor dilates, and the pupil is not altered, whatever be the quantity of light.

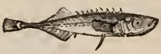
The ear of Fishes is inclosed on every side in the bones of the head, and consists merely of a sac, representing the vestibule, and of three membranous semicircular canals. In the former are suspended small hard bodies.

The sense of taste, of smell, and of touch, are regarded as feeble; although, in relation to taste, it should be stated that some fishes show a decided preference for one kind of bait over another, not only in taking it, but in clinging to it.

Most fishes are oviparous in their manner of reproduction; but some species bring forth living young. They produce a far greater number of eggs than any other vertebrates. A Salmon sometimes contains as many as 20,000 eggs; a Perch, 28,000; a Herring, 36,000; a Mackerel, 546,000; a Flounder, 1,357,000; a Sturgeon, 7,600,000; a Cod, 9,000,000; and a species of Upeneus, 13,000,000!

Some kinds, as the Breams (Fig. 333), Sticklebacks, etc., prepare a nest for their eggs, and defend them with great spirit; but most abandon them as soon as laid. With few exceptions, Fishes have no care of their young, but devour them as readily as they do any other food.

FIG. 293.



Stickleback.

The eggs of Pipe-fishes (*Syngnathus*) are received into a sort of sack or pouch, under the tail of the *male*, and thus carried about until they are hatched.

The eggs of some kinds of South American fishes adhere to the abdomen after they are laid; and the eggs of others are carried in a fold of the lips. Some kinds of South American fishes carry their newly-hatched young in their gills.

Although the lowest class of the Vertebrates, their varied forms, and colors which often rival those of precious stones and burnished gold, the wonderful power and velocity of some, the wholesome food furnished by many, and the exciting sport of their capture, combine to render Fishes subjects of great interest to the casual observer, as well as to the amateur and the professional naturalist.

The number of species of Fishes is not less than ten thousand; and their forms and structure are almost endlessly varied. This explains, in part, the reason why it is so difficult to correctly classify this group, and, in part, why so many different classifications of Fishes have been presented.*

---

* Cuvier recognized two great groups and nine Orders, as follow:

I. BONY FISHES.
1. Acanthopterygii, as Perch, Breams, etc.
2. Malacopterygii abdominales, as Salmon, etc.
3. " sub-brachiati, as Cod, etc.
4. " apodes, as Eels.
5. Lophobranchii, as Pipe-fishes, Sea-horses, etc.
6. Plectognathi, Puffers, etc.

Dr. Theodore Gill regards the group of Fishes not as one class, but as including three Classes, namely—

I. PISCES, as Fishes proper such as Rays, Sharks, Gar-pikes, Pipe-fishes, Puffers, Perch, Cod, Tautog, Salmon, etc.
II. MARSIPOBRANCHIATES, as Lampreys, Hags, etc.
III. LEPTOCARDIANS, as the Amphioxus, etc.

A classification quite extensively adopted recognizes eleven orders of Fishes. It is essentially that of Müller as modified by Owen and others; and this classification we prefer to adopt for our present purposes. In connection with this we also indicate the four groups quite generally recognized—Selachians, Ganoids, Teliosts, and

---

II. CARTILAGINOUS FISHES.	7. Chondropterygii, with free gills, as Sturgeons. 8. " with fixed gills, as Sharks and Skates. 9. Cyclostomi, as Lampreys, etc.

According to the earlier writings of Agassiz, Fishes may be divided into four Orders, the scales being taken as a basis of classification, thus:—

1. Placoids or fishes with plates or scales armed with a point, as Sharks and Rays; 2. Ganoids or fishes with enameled scales, as the Gar-pikes, etc.; 3. Cycloids or fishes with rounded scales, as Salmon, etc.; and 4. Ctenoids or fishes with toothed scales, as Perch, etc.

A later classification of Agassiz regards the group of Fishes as including four Classes—

I. Selachians, as Sharks, Rays, etc.
II. Ganoids, as Gar-pikes, etc.
III. Fishes proper, Perch, Salmon, etc.
IV. Myzontes, as Lampreys, Hags, etc.

Müller recognizes six Sub-classes of Fishes, viz.:

I. Teleostei, as all ordinary fishes.
II. Dipnoi, as the Lepidosiren.
III. Ganoidei, as the Gar-pikes, etc.
IV. Elasmobranchii, as the Rays, Sharks, etc.
V. Marsipobranchii, as Lampreys, Hags, etc.
VI. Leptocardii (Pharyngobranchii), as the Lancelet or Amphioxus.

Huxley, Rolleston, and some others, regard these six groups as Orders, and place the Dipnoi as the first. Cope recognizes five sub-classes (see his papers,).

Dermopters—writing the names so as to show their relations to the eleven Orders here adopted :—

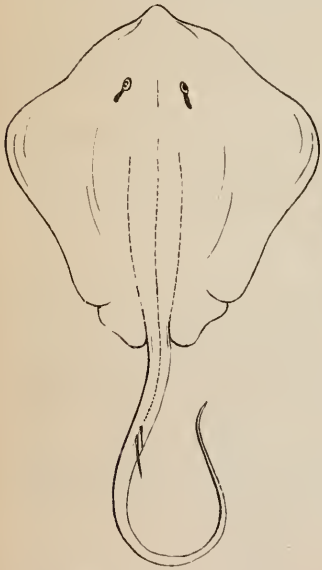
1. PLAGIOSTOMI or Selachii or Elasmobranchii. as the Rays and Sharks.	SELACHIANS.
2. HOLOCEPHALI or Chimæroids, as the King of Herrings.	
3. PROTOPTERI or Sirenoids or Dipnoi, as the Lepidosiren.	GANOIDS.
4. GANOIDEI or Ganoids, as the Sturgeons, Gar-pikes, etc.	
5. LOPHOBRANCHII or Tuft-gilled Fishes, as the Pipe-fishes, Sea-horses, etc.	TELIOSTS.
6. PLECTOGNATHI or Twisted-jawed Fishes, as the Puffers, Trunk-fishes, etc.	
7. ACANTHOPTERI or Spine-finned Fishes, as the Anglers, Mackerels, Sculpins, Perch, etc.	
8. ANACANTHINI or Spineless-finned Fishes, as the Flounders, Soles, Halibut, Cod, etc.	
9. PHARYNGOGNATHI or Gar-fishes and their allies, as the Conners, Tautog, Flying-fishes, etc.	
10. MALACOPTERI or Soft-finned Fishes, as the Pike, Carp, Salmon, Herring, Eels, etc.	
11. DERMOPTERI (including Marsipobranchii) or Skin-finned Fishes, as the Lampreys, Myxines or Hags, Lancelet or Amphioxus, etc.	DERMOPTERS.

SUB-SECTION II.

THE ORDER OF PLAGIOSTOMI OR SELACHII OR RAYS AND SHARKS.

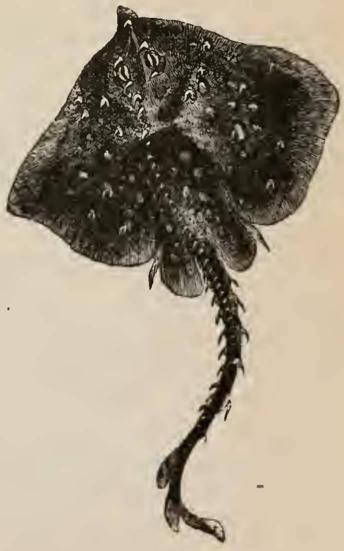
THE fishes of this group are often called Selachii or Selachians, because they have a cartilaginous skeleton, the name Selachian coming from the Greek word *selachos*, meaning cartilage. They are also called Plagiostomi, from the fact that their mouth has a peculiar form and position, being placed transversely on the under surface of the head. The word Plagiostomi comes from two Greek words, *plagios*, oblique, and *stoma*, a mouth. And they are also often called Elasmobranchii, from two Greek words, *elasma*, a strap, and *bragchia*, gills, from the peculiar nature of their gills. Instead of being free on their outer margins, as in all the more common fishes, the gills of these fishes are fixed, that is, they are attached by both margins; and the gill-openings are without gill-covers.

Fig. 294.



Sting Ray, *Trygon hastata*, Storer.

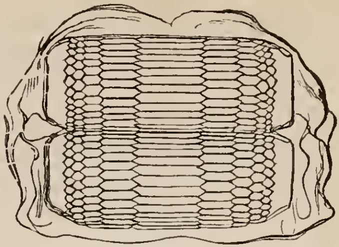
Fig. 295.



Thornback Ray.

The fishes of this great group that are known under the name of Rays or Skates or Raiæ, have the body, except in a few species, exceedingly broad and flat, with the mouth, nostrils, and gill-openings on the under surface—the eyes being on the upper surface. Their teeth are of a definite form, and set together like a pavement, and are suited to crushing shell-fish, upon which they mainly feed.

FIG. 296.



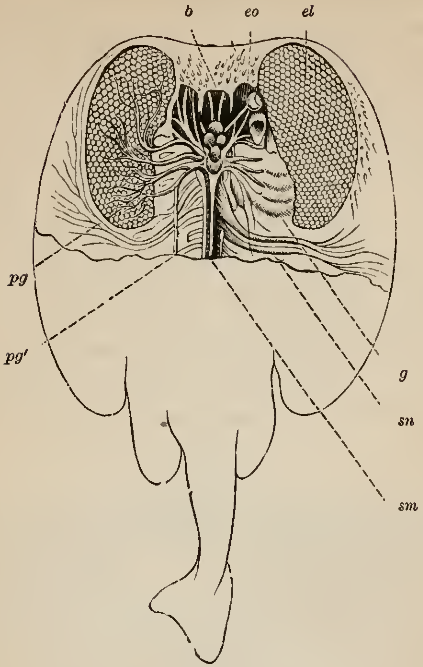
Teeth of a Ray.

The Rays vary in size from those two or three feet long to those known as Vampires, which attain the most wonderful dimensions. One of these taken off Messina weighed over half a ton. Another taken off Barbadoes is said to have required seven yoke of oxen to draw it! And Levaillant tells us of one which was twenty-five feet long and thirty feet wide!

The Rays known as Torpedoes are famous for their electric or galvanic power. These have the space between the pectorals, head, and the branchiæ, on each side, filled with a singular apparatus formed of little membranous tubes placed close together, and subdivided by horizontal partitions into small cells filled with mucus, and traversed by nerves. In this apparatus resides the electric power. Violent shocks are received by coming in contact with these fishes when alive.

The famous Saw-fishes (Fig. 298) are selachians, which in some respects are like the Rays, but their body is very much narrower, and more like that of the Sharks, and they have one feature which at once distinguishes them

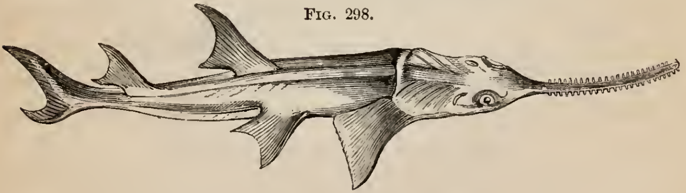
FIG. 297.



Torpedo.

b, brain; *eo*, eye and optic nerve; *el*, electric organs; *sn*, spinal nerves; *sm*, spinal marrow; *pg*, pneumogastric nerves going to the electric organs; *pg'*, branch of the preceding; *g*, gills.

FIG. 298.

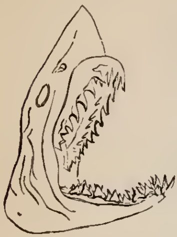


Saw-fish, *Pristis antiquorum*, Lath.

from all other fishes—a long, flat snout, armed on each side with pointed spines which are implanted like teeth.

Sharks or SQUALI are selachians which are more or less tapering, and which have a most formidable array of teeth; their gill-openings are on the sides of the neck, instead of below, as in the Rays. Sharks vary from three feet to thirty feet in length.

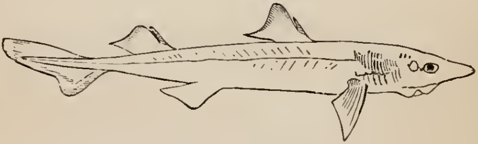
FIG. 299.



Head of Mackerel Shark.

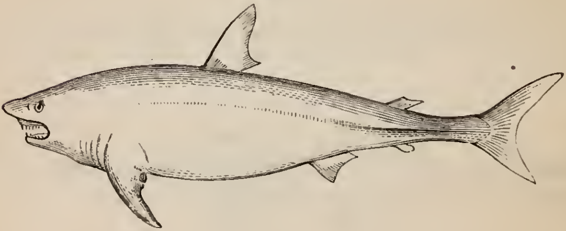
Of the large sharks it may be said that their great power, formidable teeth, and great ferocity, make them dangerous antagonists. Some kinds, as the White Sharks, have the teeth lancet-shaped, and serrated on their edges, and they can divide a man at a single bite as smoothly as if done by a sweep of a huge sword.

FIG. 300.



Dog-fish, *Acanthias americanus*, Storer.

FIG. 301.

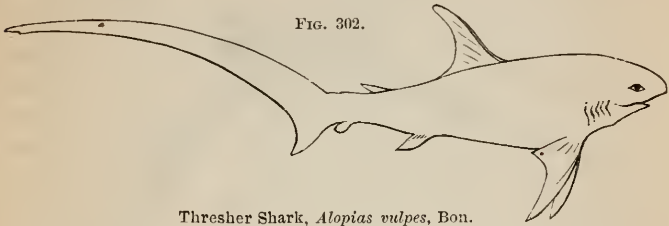


Mackerel Shark, *Lamna punctata*, Storer.

The Sharks present considerable diversity of form (Figs. 300–304). The Hammerheads (Fig. 304) have the head shaped like a double-headed hammer. The Spined

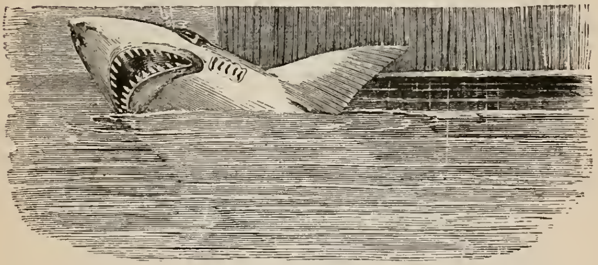
Dog-fishes (Fig. 300) have the dorsal fins furnished with strong spines. Similar fossil spines, more than two feet in length, are found in the Devonian and Carboniferous rocks. The Cestraciont Sharks, around Australia, have the mouth furnished with a pavement of bony pieces, for a masticating apparatus; the margins of their jaws, however, have ordinary teeth. The Threshers (Fig. 302) have the upper lobe of the tail excessively elongated.

Fig. 302.



Thresher Shark, *Alopias vulpes*, Bon.

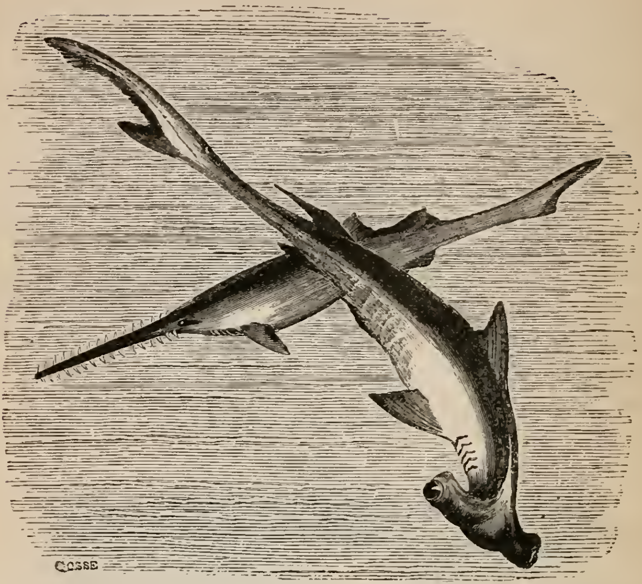
Fig. 303.



White Shark.

The eggs of Sharks and Skates are in the form of an oblong sack with the corners greatly prolonged into strings, and the covering is horn-like in consistency. The young are much developed before the eggs are laid; and in some species the young are hatched in the body of the parent, so as to make these fishes appear as true viviparous animals.

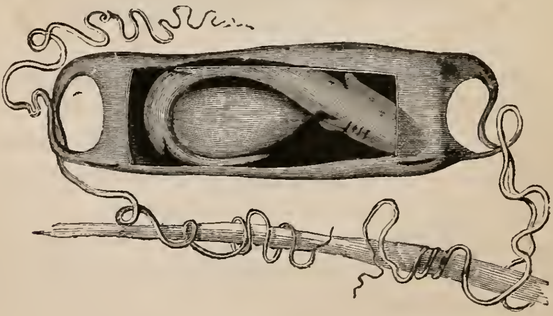
Fig. 304.



Hammerhead Shark, *Zygæna malleus*, Valenciennes; and Saw-fish, *Pristis antiquorum*, Latham.

According to Agassiz the parent and offspring in some kinds of sharks is as intimate as in the higher mammals.

Fig. 305.



Shark's Egg, with a portion of the covering removed.

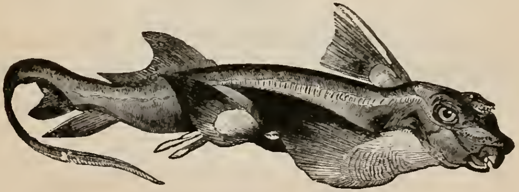
SUB-SECTION III.

THE ORDER OF HOLOCEPHALI OR CHIMÆRAS.

THE Holocephali or Chimæras are fishes of very remarkable form and structure. They are more or less allied to the Sharks, especially in the nature of their branchiæ, which have the same structure as those of the latter, but the five passages which carry the water from the branchial chambers of the Chimæras unite so as to form only one external opening; and this opening is covered by a rudimentary operculum.

The Chimæras have no upper jaw, the four upper teeth being supported upon the front of the skull; and they have only two teeth in the lower jaw. They have no backbone, the vertebral column being represented only by a chorda-dorsalis (see page 32). These fishes are three or four feet in length and belong to the cold regions.

FIG. 306.



Northern Chimæra or King of Herrings, *Chimæra monstrosa*.

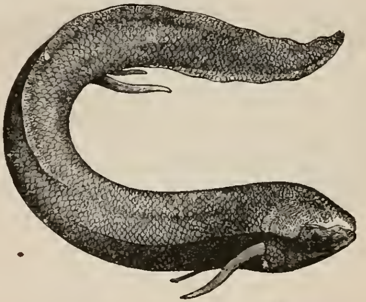
The name Holocephali comes from the Greek *holos*, whole, and *kephale*, the head.

SUB-SECTION IV.

THE ORDER OF PROTOPTERI OR LEPIDOSIRENS.

THE scientific name of this order comes from two Greek words, *protos*, first, and *pteron*, a wing or fin, and is given to fishes of this order because they have fins only in a rudimentary condition. They are called Lepidosirens or Scaly Sirens from their resemblance to the batrachians of the latter name, already noticed on page 242—the first part of the word coming from the Greek *lepis*, *lepidos*, a scale.

FIG. 307.



Protopterus or Lepidosiren or Mud-fish.

This order is also called Dipnoi, from the Greek *dis*, two, and *pnœ*, breath, in allusion to the fact that the Lepidosirens are provided with two sets of respiratory organs —both gills and lungs.

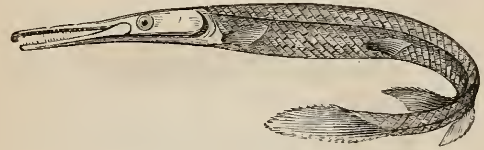
The Lepidosirens are from one to three feet long, are covered with scales, and are found in the tropical regions of America and Africa. By some writers they have been referred to the Batrachians or Amphibians.

SUB-SECTION V.

THE ORDER OF GANOIDEI OR GANOIDS.

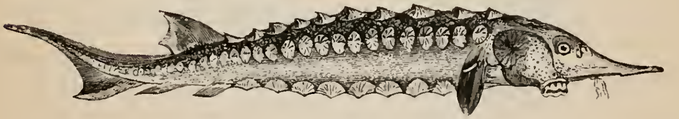
THE name of this group comes from the Greek word *ganos*, meaning brightness or splendor, and was given to the fishes of this order by Agassiz, on account of their hard shining plates or scales. The Ganoids include the Gar-pikes or Lepidosteidæ and their near allies, and the Sturgeons or Sturionidæ. The former are covered with hard enameled scales, and the latter are protected by bony plates, as seen in Fig. 309.

FIG. 308.



Gar-pike, *Lepidosteus.*

FIG. 309.



Sturgeon, *Acipenser oxyrhynchus,* Mitchell.

Sturgeons inhabit great rivers which empty directly into the sea, and they swim close to the bottom, turning up the mud and sand with their snout, and feeding on the animal and vegetable substances which they find by the aid of their feelers. They are thus real scavengers that perform a most useful work in ridding the bottom of the streams of much that would otherwise tend to make the waters impure.

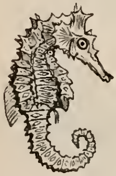
Fossil Ganoids are abundant, especially in the Devonian rocks; and these old ganoids were of enormous size, and of the most wonderful structure, having vertebrated tails and many other reptilian characteristics.

SUB-SECTION VI.

THE ORDER OF LOPHOBRANCHII OR TUFT-GILLED FISHES.

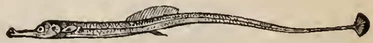
THE fishes of this group have their gills in small tufts which are arranged in pairs along the branchial arches. The name Lophobranchii is from two Greek words, *lophos*, a tuft, and *bragchia*, gills.

FIG. 310.



Sea-horse, *Hippocampus hudsonius*, Dekay.

FIG. 311.



Pipe-fish, *Sygnathus Peckianus*, Storer.

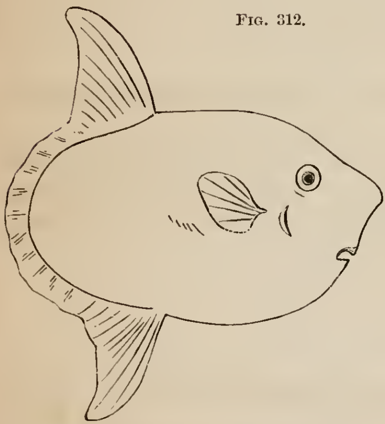
Some kinds of lophobranchs, as the Sea-horses, have the tail prehensile, with which they often cling to marine plants.

The Pipe-fishes—which, with the Sea-horses, belong to the family of Sygnathidæ—are remarkable not only on account of their form, but on account of their habits. When the eggs are laid, the male receives them into a sack, and carries them about until they are hatched! In some species the egg-sacks are on the breast or belly; in others, on the tail.

Sub-section VII.

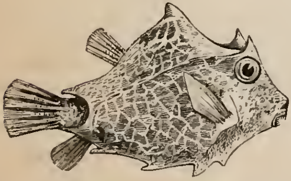
The Order of Plectognathi or Puffers, etc.

Fig. 312.



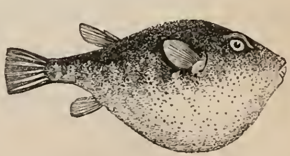
Sun-Fish, *Orthagoriscus mola*, Schreiber.

Fig. 313.



Trunk-Fish, *Lactophrys camelinus*, Dekay.

Fig. 314.



Puffer, *Tetraodon turgidus*, Mitchell.

The name Plectognathi comes from the Greek *plectos*, twisted or conjoined, and *gnathos*, jaw, and is given to fishes known as the Puffers, the Sun-fishes, etc. or the Diodontidæ, and the Trunk-fishes or Ostraciontidæ, all of which have the maxillaries and premaxillaries fixed together, and the whole united firmly by suture to the cranium. The Puffers have the power of greatly inflating themselves by swallowing air, and hence their name. The Sun-fishes (Fig. 312) have the tail so short that they appear as if their hind parts had been cut off just behind the dorsal fin. They attain a very large size. The Trunk-fishes have the head and body covered with bony plates so united that they form an inflexible shield · the mouth, tail, and fins being the only movable parts.

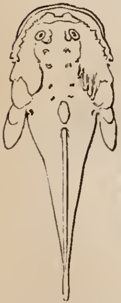
Sub-section VIII.

The Order of Acanthopteri or Spine-finned Fishes.

The Spine-finned Fishes constitute a very extensive group, whose members are easily distinguished by the fact that spines occupy the place of the first rays of the dorsal fin, or alone support the first fin of the back whenever there are two dorsals; or, in some cases, a few free spines wholly take the place of the first dorsal; and there is generally one spine to each ventral fin; and the first rays of the anal are also spines.

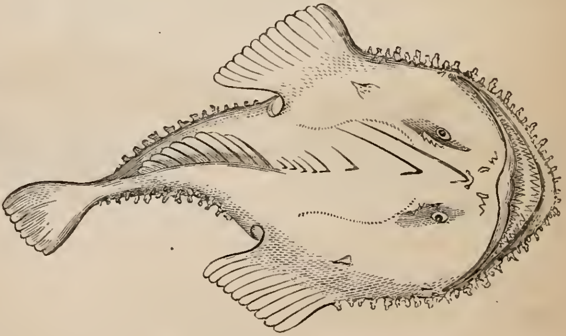
These fishes abound in the ocean, in lakes, ponds, and streams, and they vary greatly in form and size. Some,

Fig. 315.



Toad-fish, *Batrachus tau*, Lin.

Fig. 316.



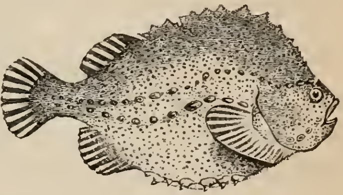
Angler or Goose-Fish, *Lophius americanus*, Cuvier.

like the Sticklebacks (Fig. 293), are very small, being only one, two, or three inches in length; others, like the Breams and Perch, Figs. 333 and 332, are six to twelve inches in length; and from these they are of all sizes up to the Tunnies of the ocean, which attain the weight of a thousand pounds or more.

Some kinds of spine-finned fishes are beautiful in form; others, as, for example, the Toad-fishes and Fishing-frogs, or Lophidæ, of the ocean, are exceedingly ugly (Figs. 315–6).

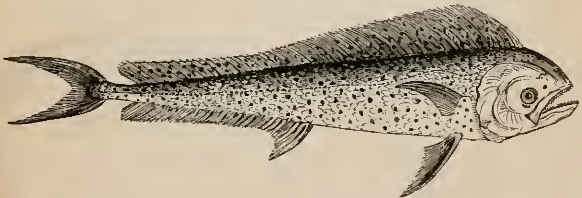
Some kinds, as the Lump-fishes or Cyclopteridæ, have a curious and strange structure. These fishes have their ventrals united into a disk or cup-shaped form. By means of this disk, they are able to attach themselves to the surface of the rocks with great firmness. Pennant states that, upon putting one into a pail of water, it adhered to the bottom so firmly that he lifted the whole pailful by taking hold of the fish by the tail. They inhabit the Atlantic, and are about a foot long.

Fig. 317.



Lump-fish, *Cyclopterus*, Linnæus.

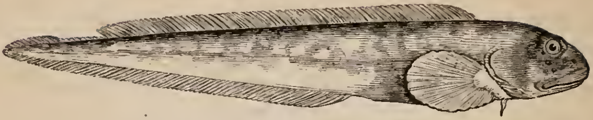
Fig. 318.



Dolphin, *Coryphæna doradon*, Cuvier and Valenciennes.

Some kinds are beautiful, mainly in form; and others, like the Dolphin (Fig. 318), have colors which rival in beauty and splendor the colors of the rainbow.

Fig. 319.

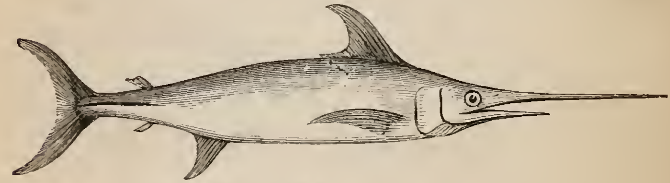


Eel-pout, Zoarces, *anguillaris*, Storer.

Some kinds, as the Eel-pouts and Wolf-fishes, are much elongated; the latter are remarkable for their formidable array of teeth.

More remarkable than any of the spine-finned fishes yet named, are the Sword-fishes, which inhabit the Atlantic and Mediterranean, and which attain a length of ten or fifteen feet, and which have their upper jaw prolonged into a very long sword-like beak.

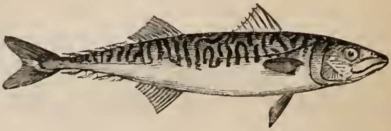
Fig 320.



Sword-fish, *Xiphias gladius*, Linn.

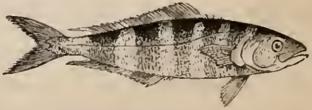
Many of the Spine-finned fishes are remarkable for their trim and neat appearance. Such are the Mackerel, Pilot-fish, Blue-fishes, etc. The Pilot-fishes have become celebrated from their habit of keeping near ships

Fig. 321.



Mackerel, *Scomber vernalis*, Mitchell.

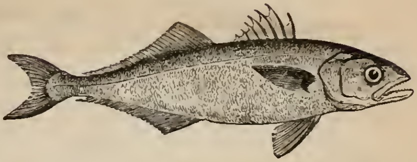
Fig. 322.



Pilot-fish, *Naucrates noveboracensis*, C. & Val.

at sea, and thus appearing, as the sailors understand it, to pilot or direct them in their course; and by many it is believed that these fishes sometimes guide the shark to his food by swimming before him.

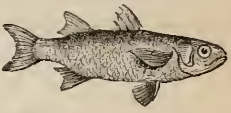
Fig. 323.



Blue-fish, *Temnodon saltator*, Cuv.

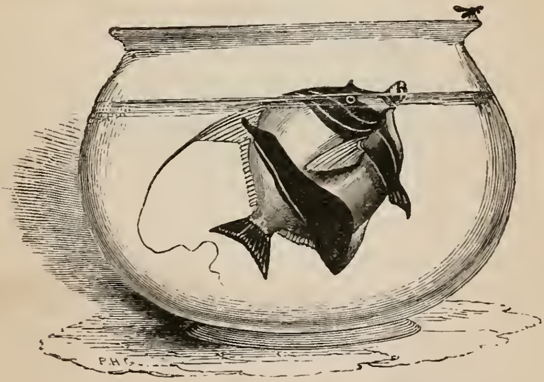
To the Spine-finned fishes also belong the Mullets, which appear in many species in both fresh and salt waters.

Fig. 324.



Mullet, *Mugil lineatus*, Mitchell.

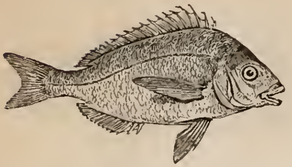
Fig. 325.



Archer, *Chætodon rostratus.*

The famous Chætodonts of the East Indies are spine-finned fishes which have the remarkable habit of spirting drops of water so as to hit and bring down insects which they see above them! (Fig. 325).

Fig. 326.

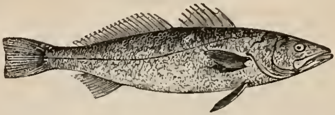


Scup or Porgee, *Pagrus argyrops*. Cuv.

The Porgees and Sheepsheads or Sparidæ, of the Atlantic, are well-known spine-finned fishes, the latter of which have their front teeth, much resembling those of man!

Next come the curious and interesting Sciænoids, known under the familiar names of Weak-fishes, Sheepsheads of our Northern and Western lakes, Umbrinas, Pogonias, etc.

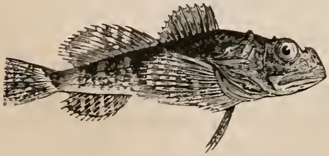
Fig. 327.



Weak-fish, *Otolithus regalis*, Cuv. & Val.

The Umbrinas are three to five feet long, and are common in the Mediterranean, where they swim in schools, and are said at times to utter a low bellowing sound! The Pogonias or Drums of the Pacific and Atlantic are large spine-finned fishes, attaining, in some cases, a weight of a hundred pounds; and they are called Drums because of the loud drumming sounds which they produce; but the way in which they make these sounds is not positively known.

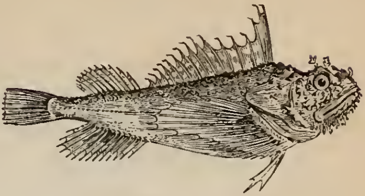
Fig. 328.



Greenland Sculpin, *Cottus grœnlandicus*. Cuv. & Val.

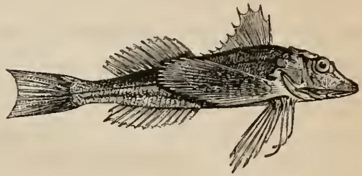
The Sea-Ravens, better known as Sculpins, and the common Sculpins or Cottidæ, are additional examples of spine-finned fishes familiar to all who live on the sea-coast. And to these we may add the Sea-Robins or Prionotidæ, and Sea-Swallows or Dactylopteridæ, remarkable for their large pectoral fins—those of the latter being so excessively developed that these fishes are able to sustain themselves in the air for a short time, thus reminding us of the so-called real flying-fishes which belong to another order.

Fig. 329.



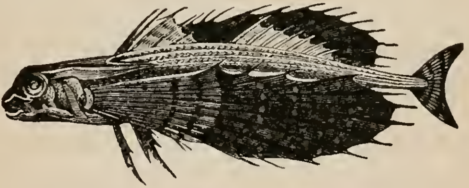
Sea-Raven, *Hemitripterus acadianus*, Storer.

Fig. 330,



Sea-Robin, *Prionotus lineatus*, Dekay.

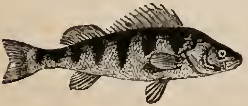
Fig. 331.



Sea-Swallow, *Dactylopterus volitans*, Cuvier.

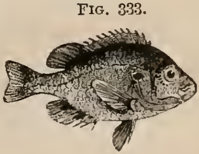
But no fishes give a better idea of the Acanthopteri than the Bass, Bream, and Perch. The two last are common in lakes, ponds, and rivers, and vary from a few

Fig. 332.



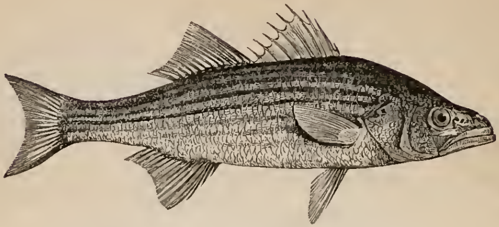
Yellow Perch, *Perca flavescens*, Cuv.

Fig. 333.



Bream, *Pomotis vulgaris*, Cuv.

FIG. 334.

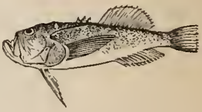


Striped Bass, *Labrax lineatus*, Cuvier.

inches to a foot in length; and the Bass are of various species, varying from a foot to four feet in length, and abound both in salt and fresh waters.

And lastly, we may mention the little Star-gazers, whose eyes are so placed that they appear as if constantly gazing at the heavens.

FIG. 335.



Star-gazer, *Uranoscopus anoplos*.

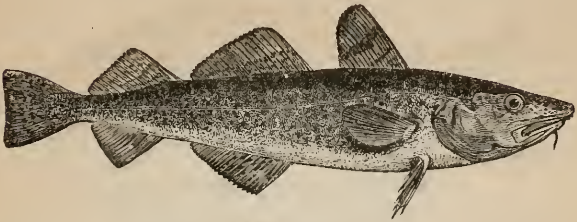
SUB-SECTION IX.

THE ORDER OF ANACANTHINI OR ANACANTHS.

THE fishes named Anacanths have their fins without spines, and supported by flexible or jointed rays, and their ventrals are either beneath their pectorals or wholly wanting.

Of all the Anacanths, none are more important than the Cods or Gadidæ, which are distinguished by their three dorsals, two anals, and a barbel at the point of the lower jaw. The Cod attains the weight of a hundred pounds in some instances. The Haddock is a cod-like fish, generally considerably smaller than the American Cod, and readily distinguished from the latter by its jet-black lateral line. The whole family of Cods inhabit cold waters, and are rarely found in the warm regions; and hence all the extensive cod-fisheries are confined to temperate and cold regions.

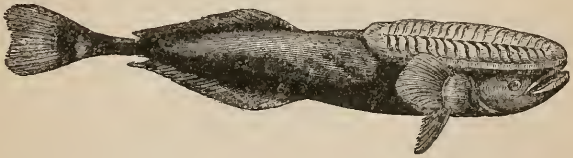
FIG. 336.



American Cod, *Morrhua americana*, Storer.

To the Anacanths belong the strange fishes known under the name of Remora or Echeneididæ. Upon the head they have a flattened disk composed of transverse cartilaginous laminæ directed obliquely backwards, and serrated or spiny on the hind edge, and movable, so that by creating a vacuum between them, or by hooking on to various bodies by means of the serrated edges, these fishes can attach themselves very firmly. They are chiefly tropical; but some are taken on the coast as far north as Labrador. They are often found attached to other marine animals. They are from twelve to thirty inches long.

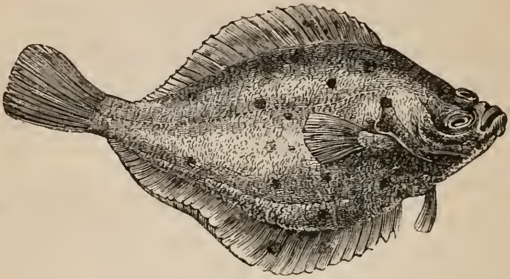
FIG. 337.



Remora, *Echeneis*.

But more strange than any other fishes belonging to this order, are those that are familiarly known under the name of Halibuts, Flounders, Soles, Turbots, etc., or Pleuronectidæ. These fishes have the body flat, being compressed vertically, and both eyes on the same side of the head, the sides of the mouth unequal, and a dorsal extending the whole length of the back. The side upon which the eyes are placed is always uppermost, and is deeply colored; while that on which the eyes are wanting is whitish. They have no swimming-bladder, and seldom quit the bottom. The want of symmetry between the two sides of the fishes of this family is seen in no other vertebrates. These strange fishes all belong to the sea, and vary in size from the Flounders, which are from six to twenty inches long or more, to the Halibuts, which, in some cases, attain a length of six or eight feet, and a weight of six hundred pounds.

FIG. 338.



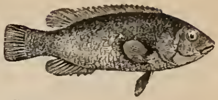
Flounder, *Platessa vulgaris*, Cuvier.

SUB-SECTION X.

THE ORDER OF PHARYNGOGNATHI, OR GARS, ETC.

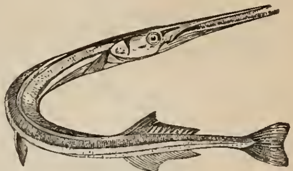
THE well known "Sea-Perch" or Conners, and the Tautogs or Labridæ, and the Scomberesocidæ or Gars and Flying-fishes, etc., have the bones known as the lower pharyngeals united so as to form one bone; and hence the name of this group.

FIG. 339.



Conner, *Ctenolabrus Burgall*, C. & V.

FIG. 340.

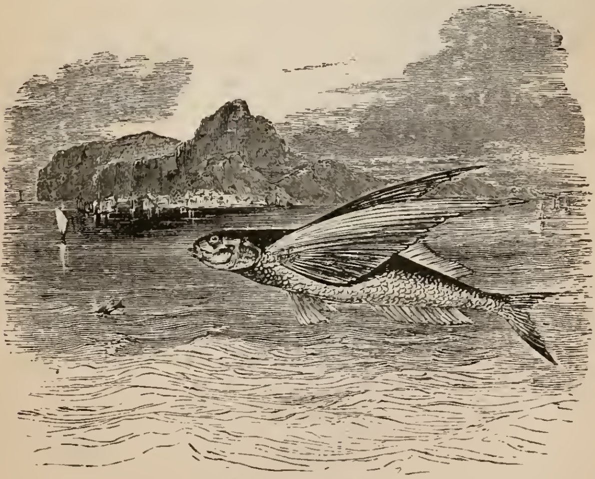


Gar-fish, *Belone truncata*, Le Sueur.

The Gars, in their general form, remind us of the Gar-pikes, which we have seen belong to the Ganoids; but they are not at all related to those fishes. The Gars are one to two feet in length, and are remarkable for their form and for the green color of their bones.

The Flying-fishes have an excessive development of the pectorals, which enable the possessors to support themselves in the air for a few moments. These fishes are found in all warm and temperate seas, and there are many species from three to twelve inches in length.

FIG. 341.



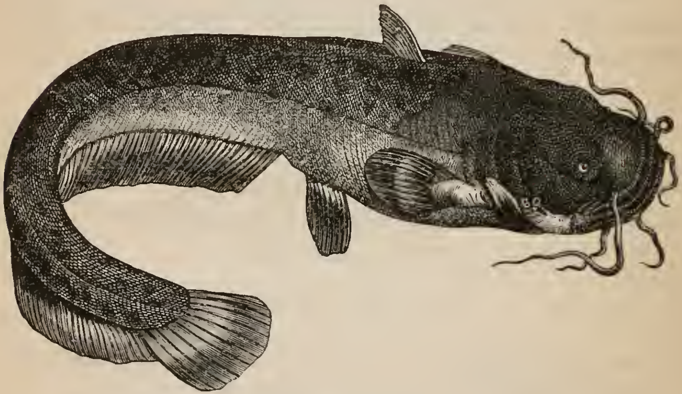
Flying-fish, *Exocœtus*.

SUB-SECTION XI.

THE ORDER OF MALACOPTERI OR SOFT-FINNED FISHES.

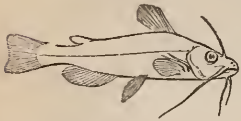
THE Fishes of this order have the fins, in nearly all cases, supported by soft or jointed rays.

FIG. 342.



Silurus, *Silurus glanis.*

FIG. 343.



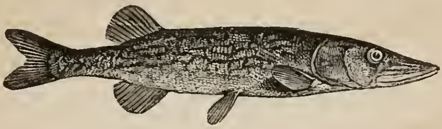
Horned Pout, *Pimelodus atrarius*, Dek.

The Siluridæ—better known as Cat-fish and Horned Pouts—have the skin naked, that is without scales; in some species, however, the skin is covered with bony plates. And in most cases the head is depressed, and has several fleshy filaments as appendages. In a majority of cases they so far fail to conform to the order of Malacopteri, that they have the first ray of the dorsal and of the pectorals composed of a strong and very sharp spine, which is so articulated that the fish can bring it close to the body or immovably extend it, thus making it a dangerous weapon. Some species of the Siluroids, as the Silurus (Fig. 342) of Central Europe, attain the weight of two or three hundred pounds.

In the order of Malacopteri comes the whole array of the Carp, Dace, Shiners, or Cyprinidæ, and the Suckers or Cacostomidæ, so abundant in the fresh waters.

Quite in contrast to the Carp and the other soft-finned fishes just noticed, are the various members of the group known under the name of Pike and Pickerel or Esocidæ.

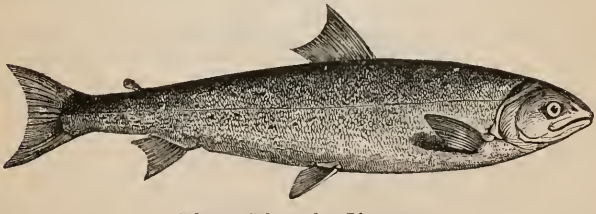
FIG. 344.



Pickerel, *Esox reticulatus*, Le Sueur.

These have the body long, the mouth very large, and the single dorsal placed very far behind.

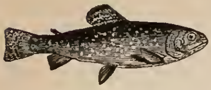
FIG. 345.



Salmon, *Salmo salar*, Linnæus.

But none of the Malacopters are more interesting than

FIG. 346.

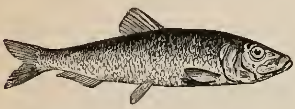


Trout, *Salmo fontinalis*, Mitchell.

the Trout, Salmon, and the other members of the large and highly important family of the Salmonidæ.

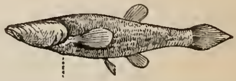
The fishes known as Alwives, Shad, Pilchards, Herrings, etc. or Clupeidæ, are malacopters which have a very compressed body, and the lower portion forming a more or less serrated edge.

FIG. 347.



Herring, *Clupea elongata*, Le Sueur.

FIG. 348.

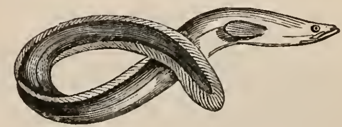


Blind-fish, *Amblyopsis spelæus*, Dek.

Very different from any of the Malacopters hitherto noticed is the Blind-fish or Amblyopsidæ of the Mammoth Cave in Kentucky. This celebrated fish is about three inches long, and the vent is before the base of the pectorals, at the point indicated by the dotted line in the wood-cut, and the eyes are concealed under the skin.

To the Malacopters also belong the various families of Eels—the electrical Eels or Gymnotidæ, the common Eels or Anguillidæ, the Muræuæ or Murænidæ of the Romans, and others.

FIG. 349.



Eel, *Anguilla bostoniensis*, Le Sueur.

The Electrical Eels inhabit the rivers and fresh-water lagoons of the warm parts of South America, and some of the species are five or six feet long, and are able to give such electrical shocks that men and animals are often struck down by them when they go into the water where these fishes abound.

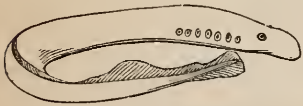
The Roman Murænæ are eels common in the Mediterranean. They were highly prized by the Romans, who kept them in ponds and fed them; and they had a custom of placing them alive on the table, in crystal vases, that their guests might admire the variegated colors.

SUB-SECTION XII.

THE ORDER OF DERMOPTERI OR MARSIPOBRANCHII OR LAMPREYS, ETC.

THE fishes which belong to this group are the lowest known to naturalists. They are more or less worm-like in general appearance, and have neither pectorals nor ventral fins, and the vertical fins, even when present—in some cases, they are wholly wanting—are without hard rays, being extremely soft and delicate. Hence, the name Dermopteri, from the Greek *derma*, skin, and *pteron*, fin. Another name applied to this order, Marsipobranchii, comes from the Greek *marsipos*, a pouch, and *bragchia*, gills, and alludes to the pouch-like gills of some of these fishes. The Dermopters include the Lampreys, Hags or Myxines or Myxinidæ, and the Lancelet or Amphioxus or Amphioxidæ.

FIG. 350.



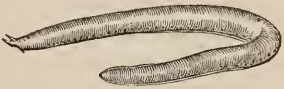
Lamprey, *Petromyzon americanus*, Le Sueur.

The Lampreys or Petromyzonidæ have the branchial or breathing organ of each side divided by transverse partitions into seven cavities or pouches which receive water from a canal which is distinct from the œsophagus, and which has as many lateral holes as there are cavities; and they have seven branchial or gill openings on each side of the neck; and the nostril is single, tubular, and on the top of the head. But one of the most curious features of these animals is the mouth; this is circular, and the tongue moves forward and backward in it like a piston, enabling them in this way to produce a vacuum, and thus to fix themselves firmly to stones or other bodies. The word Petromyzon, the name of the genus which contains most of these animals, comes from two Greek words, *petros*, a stone, and *muzo*, to suck. They often attach themselves to various substances.

Some species of the Lampreys live in the sea, and ascend rivers to lay eggs; others live wholly in fresh-waters.

The Hags or Myxinidæ, like the Lampreys, have a circular mouth, and a tongue which acts as a piston in exhausting the air from the mouth, thus enabling them to fix themselves firmly to other fishes.

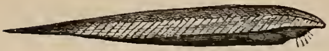
Fig. 351.



Hag or Myxine, *Myxine limosa*, Girard.

The Amphioxus or Lancelet is the lowest of all the vertebrates. So little does it appear like a vertebrate, that Pallas, the naturalist who first described it, supposed it to be a slug or sort of snail-like animal. It is found among the rocks of the sea-coast, and is about one or two inches in length. It is partially transparent, has no

FIG. 352.



Lancelet or Amphioxus, *Branchiostoma.*

skeleton, no proper head, and only a mere longitudinal slit for the mouth, which is wholly destitute of jaws and teeth.

PRINCIPAL TOPICS CONSIDERED IN CHAPTER II., SECTION VI.

SUB-SECTION I.

Fishes considered as a Class.——Their general structure and functions.——Classification.

SUB-SECTION II.

Plagiostomi or Selachii.——Rays or Skates.——Saw-fishes.——Sharks.

SUB-SECTION III.

Holocephali or Chimæras.——Their structure and where found.

SUB-SECTION IV.

Protopteri or Lepidosirens. —Origin and meaning of the name.——Structure, size, and where found.

SUB-SECTION V.

Ganoidei.——Gar-pikes.——Sturgeons.——Fossil Ganoids.

SUB-SECTION VI.

Lophobranchii.——Origin of the name.——Pipe-fishes.——Sea-horses.

SUB-SECTION VII.

Plectognathi.——Puffers.——Sun-fishes.——Trunk-fishes.

SUB-SECTION VIII.

Acanthopteri or Spine-finned fishes.——Toad-fishes, etc.——Lump-fishes.——Dolphins.——Eel-pouts.——Sword-fishes.——Mackerels.——Pilot-fishes, etc.——Mullets.——Chætodonts. —— Porgees. —— Weak-fishes. —— Sculpins, etc. —— Perch. —— Breams.——Bass.——Star-gazers.

SUB-SECTION IX.

Anacanthi.——Cods, etc.——Remora.——Flounders, Halibuts, etc.

SUB-SECTION X.

Pharyngognathi.——Tautogs.——Gars.——Flying-fishes.

SUB-SECTION XI.

Malacopteri.——Cat-fish, etc.——Carp, etc.——Pike, etc.——Trout and Salmon.——Shad, etc.——Blind-fish.——Eels.

SUB-SECTION XII.

Dermopteri.——Lampreys.——Hags or Myxines.——Amphioxus or Lancelet.

For the most recent Classification of Fishes see Dr. Theodore Gill's "Arrangement of the Families of Fishes." —*Smithsonian Miscellaneous Collections.*

CHAPTER III.

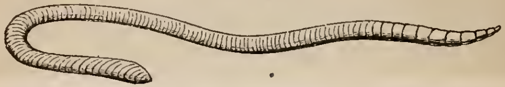
THE ARTICULATA OR ARTICULATES.

SECTION I.

THE ARTICULATA CONSIDERED AS A BRANCH.

THE Branch of Articulata includes all animals which are divided transversely into rings or joints more or less movable upon one another, and which have no internal skeleton, but whose hard parts, even when present, are external. Hard parts are wholly wanting in many cases.

FIG. 353.



Articulate animal. Earth-worm, *Lumbricus terrestris*, Linnæus.

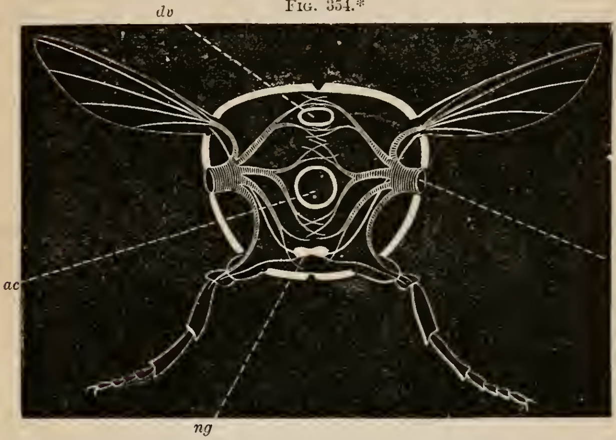
The limbs—when present—are also composed of rings or segments. In a word, the Articulates, in their structure, are essentially jointed cylinders more or less modified.

The external covering of the Insecta and Crustacea—the two highest classes of the Articulates—is hornlike in appearance, and consists mainly of a substance which chemists call *chitine.*

All articulate animals very distinctly exhibit bilateral symmetry; that is, the parts are alike on the two sides of the median line of the animal. And there is also more or less of antero-posterior symmetry, or correspondence between the anterior and posterior half of the animal.

The alimentary canal of the Articulates lies in the central line of the body; above it is the dorsal vessel or heart, which is the principal organ of the circulatory system, arteries and veins being but little developed, the blood occupying all spaces not filled by the internal organs and tissues.

FIG. 354.*



Transverse section of an Articulate animal—Bee—introduced here to show the relative position of the alimentary canal *ac*; heart or dorsal vessel *dv*; and nervous ganglia *ng*.

The nervous system consists of a sort of brain lying above the œsophagus, from which two threads, passing around the œsophagus, extend beneath the alimentary canal, along the floor of the general cavity of the body, and connect at certain distances small nervous centers or ganglia, whence arise the nerves of the body and limbs. Each of these nervous centers seems to fulfill the functions of a brain to the surrounding parts, and preserves their sensibility for a greater or less length of time after the animal has been

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* Figs. 354, 357–360, 363–4, 366, 383–4, 426, 442, 467, 469, 470, 472, 474, from Packard's "Guide to the Study of Insects."

divided. The number of these nervous centers is generally the same as the number of the segments (somites) of the body.

The Branch of Articulata is the equivalent of the Sub-Kingdoms of Arthropoda and Vermes recognized by some authors.* It is also about the same as the Annulosa of Huxley. The Articulate plan is carried out in three different ways, giving three Classes:

I. INSECTA or Insecteans, or articulate animals whose respiration is aërial; their respiratory apparatus consists of a system of air-tubes or tracheæ—in some cases, as in Spiders, of lung-like cavities—which receive air through air-holes or stigmata on the sides, or posterior part of the body; as Bees, Butterflies, Flies, Beetles, Bugs, Grasshoppers, Spiders, Centipedes, etc.

II. CRUSTACEA or Crustaceans, or articulates which are aquatic in their mode of respiration; their respiratory apparatus consists of gills or branchiæ. These articulates are covered with a hardened skin or crust; as Crabs, Lobsters, Shrimps, Sand-fleas, Barnacles, etc.

III. VERMES or Worms, or the simplest forms of articulates, or those made up of many similar segments, with no division into regions such as are seen in Insecteans and Crustaceans, but like the latter effecting respiration by means of gills or gill-like organs, and living in water or in moist places.

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* Gegenbaur, Rolleston, and some others, recognize seven Branches or Sub-Kingdoms, thus:

Sub-Kingdoms 1. VERTEBRATA. 2. MOLLUSCA. 3. ARTHROPODA. 4. VERMES. 5. ECHINODERMATA. 6. CŒLENTERATA. 7. PROTOZOA.

ARTHROPODA (Insects, Spiders, Myriapods, and Crustaceans), and VERMES (Worms proper and their allies), in this classification, are equivalent to the old Branch *Articulata.* And the ECHINODERMATA (Sea-cucumbers, Sea-urchins, Star-fishes, and Crinoids), and CŒLENTERATA (Jelly-fishes proper, Polyps, and Hydroids), are equivalent to the old Branch *Radiata.*

The word Vertebrata comes from the Latin *verto*, to turn; Articulata, from the Latin *articulus*, diminutive of *artus*, a joint; Mollusca, from the Latin *mollis*, soft; Radiata, from the Latin *radius*, a ray or spoke; Arthropoda, from the Greek *arthron*, a joint, and *pous*, a foot; Vermes, from *verto*, to turn; Echinodermata, from the Gr. *echinos*, a hedgehog, and *derma*, skin; Cœlenterata, from the Gr. *koilos*, hollow, and *entera*, viscera; and Protozoa, from the Gr. *protos*, first, simplest, and *zoön*, animal.

SECTION II.

THE CLASS OF INSECTA OR INSECTEANS.

Sub-section I.

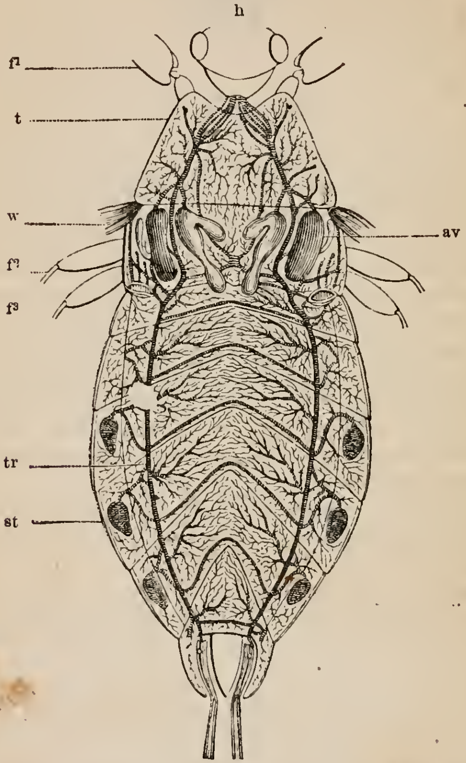
The Insecta Considered as a Class.

The vast numbers of insects, their varied forms, beautiful and in many cases splendid colors, their wonderful structure and transformations, and their not less wonderful instincts and habits, and the intimate and important relations which they sustain to other animals and to Man, combine to render the study of Entomology—from the Greek *entomon* an insect, and *logos* discourse—exceedingly fascinating and highly important.

The important relations which insects hold to man, and the corresponding importance of Entomology, are but little understood except by those who have given some attention to these animals and to this important branch of science. Few realize the fact that some kinds of insects destroy millions of dollars worth of property annually in every country, and that other kinds furnish the world with many of the comforts and even with the luxuries of civilized life—with silks, satins, and velvets, and with dyes whose fame is as old as history and as wide as the civilized world ; and even with every drop of black ink used by the schoolboy, accountant, philosopher, and poet.

Insects are articulates whose respiratory apparatus generally consists of a system of air-tubes which branch throughout the animal, and which receive the air through air-holes, called stigmata, arranged along the sides or posterior part of the body; some kinds, however, effect respiration by means of lung-like cavities in the body.

Fig. 355.



Respiratory apparatus of an Insect—Water Scorpion, enlarged.

h. head ; f^1, f^2, f^3, base of first, second, and third pair of feet ; *t*, first ring of the thorax ; *w*, base of wings ; *av*. aërial vesicles ; *tr*, tracheæ ; *st*, stigmata.

As in all other articulated animals, the alimentary canal of Insects occupies the central line of the body, and above it is the dorsal vessel or so-called heart (Fig. 354).

Insects constitute by far the largest class in the Animal Kingdom. About 200,000 species of insects are already known, and the whole number may be safely estimated as high as 300,000 species. The species are mostly small —many are microscopic in size; but some kinds in the warm regions are several inches, even a foot, in length. The average length, however, is probably much less than one inch. This vast class comprises three Orders:

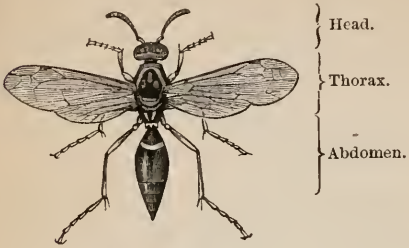
1. HEXAPODA or Six-footed Insects or Insects proper: with body exhibiting *three* distinct regions; generally two pairs of wings —in some kinds the wings are wholly wanting, and the Flies and their allies have only one pair of wings—three pairs of thoracic legs; both compound and simple eyes; and in passing from the egg-state to maturity they undergo a more or less complete metamorphosis.
2. ARACHNIDA or Spiders, with the body exhibiting only *two* distinct regions, a cephalo-thorax and an abdomen; no wings; four pairs of thoracic legs; in many cases, three pairs of jointed abdominal appendages; simple eyes; no antennæ; and in passing from the egg state to maturity they undergo no metamorphosis.
3. MYRIAPODA, as "Galley-worms," Centipedes, etc.; with the body worm-like, exhibiting *no* grouping of the segments into regions in the adult state; no wings; "feet" numerous; head free; antennæ present; eyes simple; no metamorphosis, except that the yolk-sac is present a short time after hatching.

SUB-SECTION II.

THE ORDER OF HEXAPODA OR INSECTS PROPER.

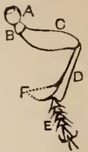
THE Insects proper, or the best representatives of the great group of the Insecta in general, are insects which have their body divided into three plainly marked regions —the *head*, *thorax*, and hind body or *abdomen*. The head is furnished with *mouth*, *eyes* and *antennæ;* to the thorax are appended the *legs* and *wings;* and the abdomen contains the principal *organs of digestion* and other viscera, and to it also belong the piercer and sting with which many kinds of insects are provided. Insects proper have only six legs—and hence are often called

FIG. 356.



An Insect Proper.

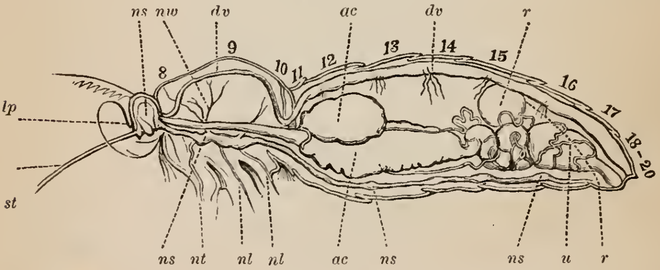
FIG. 357.



Leg of an Insect Proper.

A, coxa; B, trochanter; C, femur; D, tibia; F, tibial spurs; E, tarsus composed of five tarsal joints, the last one ending in a claw.

FIG. 358.



Anatomy of an Insect—*Sphinx ligustri.*

st, spiral tongue or modified maxillæ; *lp*, labial palpi; *ac*, alimentary canal, forming a straight tube in the head and thorax, but a crop and chyle-forming stomach in the abdomen; *ns*, main portion of the nervous system, exhibiting the largest nervous mass in the head; *nw*, nervous threads going to the wings; *dv*, dorsal vessel or heart; *nl*, nervous threads going to the legs; *u*, urinary vessels; and *r*, reproductive organs; 8–10, segments of the thorax; 11–20, segments of the abdomen.*

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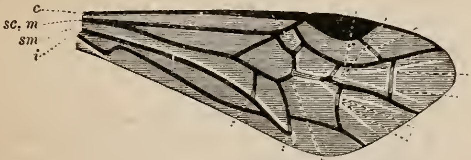
* According to the latest views, there are four segments in the head of Hexapods; two in the head of Arachnids; and four in the head of Myriapods.—Packard.

Hexapod Insects—and these are attached to the under side of the thorax, *one pair to each of the three rings* of which the thorax is composed. The leg consists of the *hip-joint*, by which it is fastened to the body, the *thigh*, the *shank*, and the *foot*, the last consisting generally of five pieces placed end to end and called *tarsi*, and generally armed at the end with one or two claws. The fore legs are directed forward, and the two hind pair backward. The wings *are normally four*, but in some, as in Flies, etc., there are only two, and in others, as in Fleas, etc., these organs are wholly wanting.

The wings of insects are at first little soft sac-like bodies containing tracheæ. They grow from the side of the thorax of the pupa at points above the insertion of the legs. During the pupa stage they are pad-like, but when the pupa-skin is shed, they rapidly expand with air and become broad and delicate wings. *The wings of insects are thus simply expansions of the general covering of the body spread over a net-work of horn-like veins or tubes.* These tubes are double, consisting of a central air-tube enclosed within a larger tube filled with blood; and hence the aëration of the blood is also carried on in the wings, and thus these organs serve the purpose both of respiratory organs and of flight. And it may be further remarked here that the number and position of these veins or tubes are of very great importance in classifying the genera and species of insects. The typical number of primary veins is five. They diverge from the base of the wing, and divide into veinlets, from which cross veins arise,

FIG. 359.



Fore wing of a Saw-fly showing Venation.

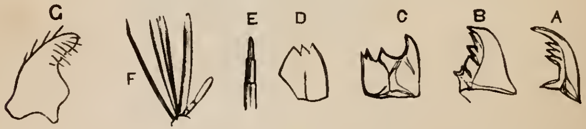
c, costal vein; *sc*, sub-costal; *m*, median; *sm*, sub-median; *i*, internal; and the spaces inclosed by the veins are—going from the front edge backward—the costal, sub-costal, median, sub-median, and internal cells. The opaque space is called the *pterostigma*.

altogether forming a net-work of veins and veinlets. The five main veins, beginning at the front edge, are the *costal*, the *sub-costal*, the *median*, the *sub-median* and *internal.* Sometimes the median divides into two. The front or costal vein is undivided; the sub-costal and median are divided into several branches; the sub-median and internal are generally simple.

The piercer mentioned above is properly an ovipositor, and is in some cases a jointed tube, and is used for conducting eggs into holes where they are to be left to be hatched; in other cases it is a scabbard containing a central borer, or saws in some cases, which are used in making holes in which eggs are to be deposited. The *sting* with which many insects, as bees and wasps, are provided is merely *a modified ovipositor*, and consists of a sheath covering a sharp instrument for inflicting wounds, and connecting with it inside of the body is a sac of poison.

The digestive system of insects is quite complicated. It consists of a mouth variously modified in the different groups, a pharynx, a gullet, a first stomach or crop, a second stomach or gizzard, a small intestine, etc. In some kinds the mouth parts are modified for biting and chewing purposes; in others they are so modified as to be adapted for sucking organs. The parts called *mandibles* are situated on each side of the mouth opening, and they vary greatly in form and size. They usually consist of

Fig. 360.

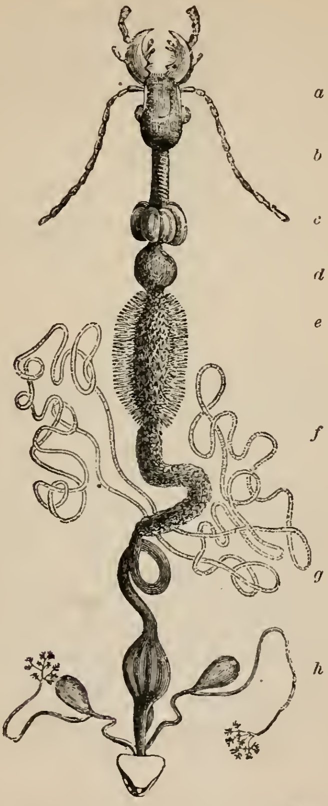


Mandibles of different Insects.

A. Beetle; B. Grasshopper; C. Dragon-fly; D. Wasp; E. Bedbug, (in which mandibles, maxillæ, and labium are united to form the beak or jointed sucker); F. Musquito (with bristle-like mandibles); G. Cock-chafer.

a single joint; and this joint or part is often subdivided into three parts, each ending in a sort of tooth for the purpose of cutting food. The cutting edges are opposed to each other, or overlap, and their motion is horizontal

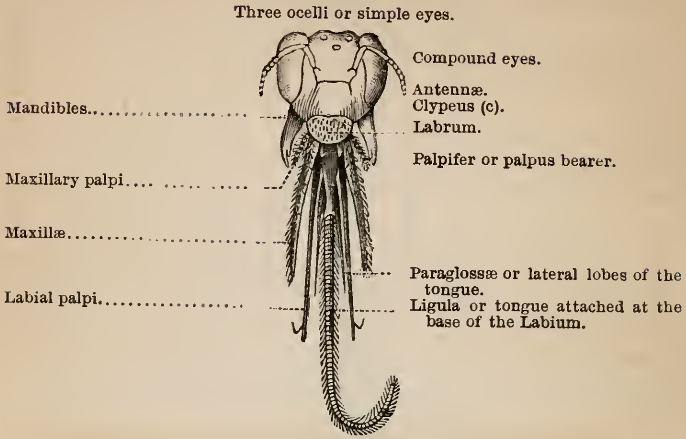
FIG. 361.



Digestive Apparatus of an Insect—Beetle Magnified.

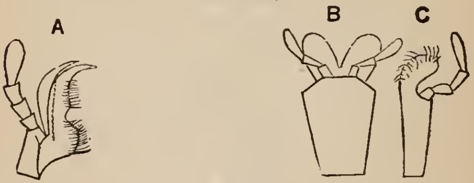
a, head, jaws, etc.; *b*, œsophagus; *c*, crop; *d*, gizzard; *e*, chylific stomach; *f*, biliary vessels; *g*, intestine; *h*, secreting organs; *i*, vent.

Fig. 362.


Three ocelli or simple eyes.
Compound eyes.
Antennæ.
Clypeus (c).
Labrum.
Palpifer or palpus bearer.
Mandibles.
Maxillary palpi.
Maxillæ.
Paraglossæ or lateral lobes of the tongue.
Labial palpi.
Ligula or tongue attached at the base of the Labium.

Front view of the Head of a Bee.

Fig. 363.



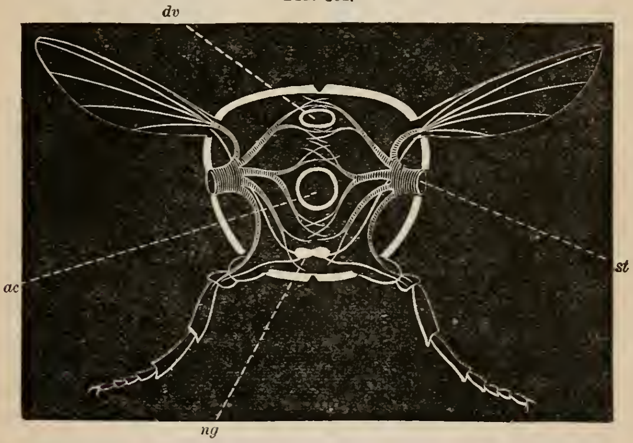
Maxillæ.

A, maxilla with two lobes, and the palpifer bearing the four-jointed palpus; *B*, mentum and labial palpi; *C*, one maxilla with palpus.

or sidewise, instead of vertical, as in the motion of the jaws of vertebrated animals. The parts called *maxillæ* are much more complicated organs than the mandibles, and are inserted on the under side of the head, and just behind the mouth. Their function is to seize food and retain it within the mouth and to aid the mandibles in comminuting it. Each maxilla consists of a basal joint, beyond which it is divided into three lobes—namely, the footstalk, the palpus-bearer, and the blade. The *maxillary* *palpi* are slender, jointed organs, very flexible and sensitive.

A highly developed circulatory system is wanting; but just under the covering of the back there is a long tube which is called the heart, and this organ performs regular alternate movements of contraction and dilatation. The blood enters this tubular organ by openings along its sides, the openings being furnished with valves which prevent its return, and the blood escapes at the forward end as the organ contracts, and thus the blood is kept in motion throughout the interior of the animal. The blood of Insects is colorless, and it fills all the interior of the animal not occupied by internal organs, and it permeates the tissues of the organs themselves.

FIG. 364.

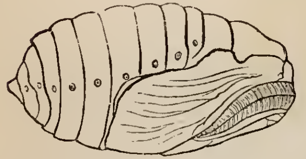


Cross section of an insect—Bee - showing position of stigmata, air tubes, etc.

st, stigmata opening into the tracheæ; *dv*, dorsal vessel or heart; *ac*, alimentary canal; *ng*, nevous ganglia.

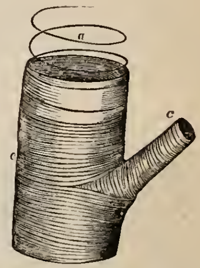
The respiratory system is very different from that of the higher animals. On the sides of the body are breathing-holes or stigmata, generally nine on each side, and these open into air-tubes called tracheæ, which branch throughout the body, carrying air into every part, and thus aërating the blood in the most perfect manner, and thereby fitting these animals for rapid and long-continued motion. These air-tubes each consist of two membranes enclosing between them a spirally-coiled fiber, thereby giving them great strength and flexibility.

FIG. 365.



Pupa of Cecropia Moth—cocoon removed—showing breathing-holes or stigmata; also an antenna, and the pad-like members which in the adult state expand into broad wings.

FIG. 366.



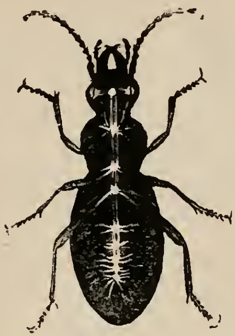
Portion of a trachea, enlarged. *a*, the fiber which is closely wound around the trachea as at *e*; *c*, a branch.

The muscular system of Insects consists of straight fibers, more or less isolated, and not gathered into bundles as in the vertebrates, but in many cases they are striated, as in the latter branch. The muscles are colorless, or transparent, or yellowish-white, and very soft. The muscles are exceedingly numerous. Lyonnet found 3,993 muscles in a single larva, 228 of these being in the head. The muscular power of Insects is enormous. It is stated that the flea can leap two hundred times its own height; that beetles have been known to gnaw through lead pipes;

and that the European Stag-beetle (*Lucanus cervus*) has gnawed a hole an inch in diameter through the side of an iron canister in which it was confined!

Their nervous system, as already stated, consists of a series of ganglions or knots of nervous matter connected by two longitudinal nervous cords or threads; and these are situated along the ventral side of the animal, connected, however, with a nervous centre in the head. From these ganglia arise the nerves of the body and limbs (Figs. 358, 364, and 367).

FIG. 367.

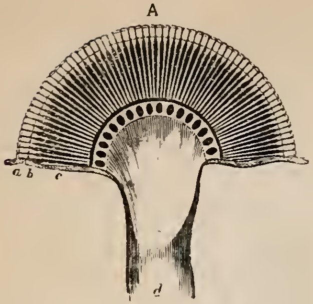


Nervous system of an Insect—Beetle.

The organs of sight in Insects consist of ocelli and eyes. Theoretically, the ocelli are the most anterior organs of the head, but in the process of development they are carried backward, so that in the adult insect they appear on top of the head. The ocellus is the simplest form of the eye.

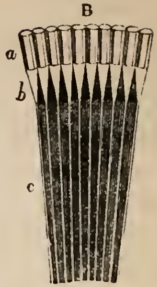
The ocellus consists of a "very convex, smooth, single cornea, beneath which is a spherical crystalline lens, resting upon the plano-convex surface of the expanded vitreous humor, the analogue of the transparent cones of the compound eyes."

Fig. 368.



Section of the Eye of the Cockchafer (*Melolontha vulgaris*), highly magnified.

Fig. 369.



B, a portion of A more highly magnified.

a, facets of the corneæ; *b*, pyramids surrounded with pigment; *c*, fibres of the optic nerve; *d*, trunk of the optic nerve.

The ocelli constitute the only visual organs of most of the Myriapods, of all the Arachnids, and of the larvæ of many of the Hexapod Insects. The number of ocelli in adult insects is generally three. (See Fig. 362.)

The real eyes of Insects are compound, being made up of a very many simple eyes. During the development or growth of the insect the simple eyes of the larvæ increase in number, and at length coalesce to form the compound eye. The number of facets or corneæ in the compound eye is very great in some kinds of insects, 3,650 having been counted in the eye of a butterfly. The form of the facets is generally hexagonal, but in some species it is quadrangular.

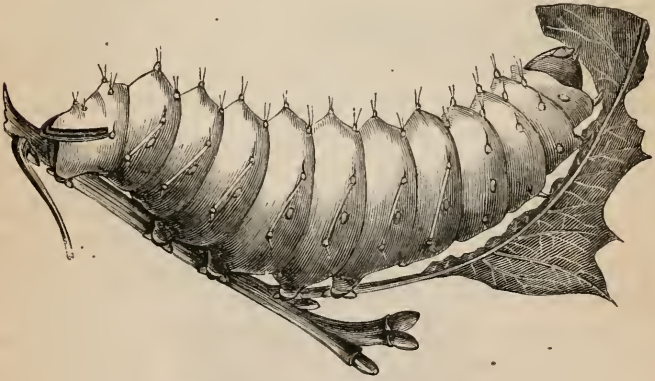
As to the organs of hearing, smell, taste, and touch, but little is positively known. The antennæ seem to serve the purpose of feelers, and it is believed that they are also connected with the sense of hearing. But it should be remarked here that Siebold found an auditory apparatus in the fore legs of some species of grasshoppers.

Insects are produced from eggs, which are hatched after they are laid in some favorable place; or, in some cases, they are hatched in the body of the parent insect, and then brought forth as moving forms.

In passing from the egg state to the adult state, Insects undergo great changes of form and habit. These changes are called *transformations* or *metamorphoses;* and they are so great in most cases that the same insect at different ages may easily be mistaken, by one not an entomologist, for as many different animals. There are at least three more or less distinctly marked forms, or stages, or states in the life of every insect after it leaves the egg—the *Larva* (Figs. 370, 371, 374), the *Pupa* or *Chrysalis* (Figs. 365, 372, 375), and the *Imago* state (Figs. 373, 376).

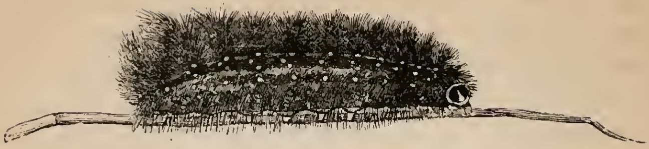
In the *larva* state Insects are more or less worm-like, and consist of thirteen or more apparent segments, one of these being the head; and they pass most of their time in eating, and as a consequence of this they grow very

FIG. 370.



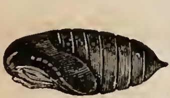
Polyphemus Moth, *Telea polyphemus*, Fabr., in the larva stage.

FIG. 371



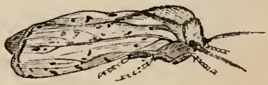
Salt-marsh Moth in the Larva state.

FIG. 372.



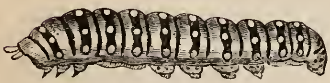
Salt-marsh Moth in the Pupa or Chrysalis state.

FIG. 373.



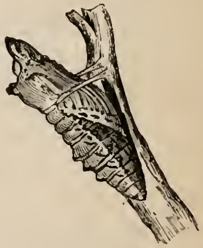
Salt-marsh Moth in the Imago state.

FIG. 374.



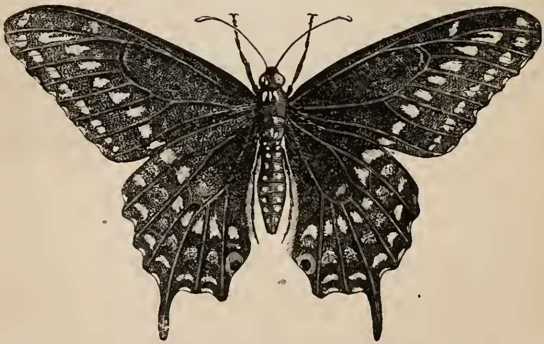
Asterias Butterfly in the Larva state.

FIG. 375.



Asterias Butterfly in the Pupa state.

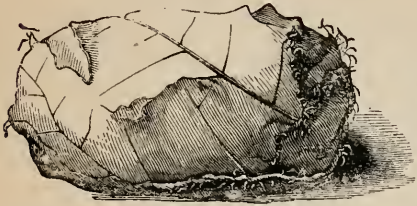
FIG. 376.



Asterias Butterfly in the Imago state.

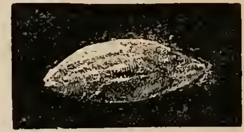
rapidly. When the larva of an insect has attained its full growth as a larva, it retires to some suitable place, and in many cases it spins a silken covering called a cocoon, then sheds its skin, and appears as a much shortened, oblong, oval, or conical body, apparently lifeless; in this form it is called a *pupa* or *chrysalis*. In a majority of species, however, no silken covering or cocoon is made; but in such cases the pupa is essentially of the same form as those enclosed in a cocoon. At the end of the pupa state, which varies greatly in duration in the different species, the insect sheds its pupa skin and comes forth fully grown, and in most species provided with wings; and in this state it is called a perfect insect or *imago*.

FIG. 377.



Cocoon of Silk-worm Moth (*Telea Polyphemus*), wrapped in a leaf.

FIG 378.



Cocoon of Tent Caterpillar, *Clisiocampa americana.*

It is held by some that the imago and pupa skins are really already formed under the skin of the larva.

After insects enter upon the adult or imago state they do not increase in size. They now provide for a continuation of their species, and then, in most cases, soon perish.

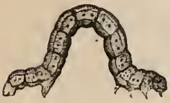
All insects which pass through the changes described above are said to undergo a complete metamorphosis or transformation.

But there are some kinds of insects which do not apparently pass through all the changes enumerated above, but whose larvæ pass by insensible gradations to the pupa state, and from the latter to the perfect insects, all the while remaining in a state of activity. These are said to undergo only a *partial transformation*.

The grasshopper, for example, is hatched from the egg as a wingless insect. It eats voraciously, grows rapidly, hops about without the use of wings, sheds its skin more or less regularly, and appears after each shedding with longer wings and more completely developed limbs, until at length it ceases to grow, and then, shedding the skin for the last time, comes forth an imago or adult grasshopper.

The larvæ of those insects which undergo only a partial transformation have only six legs, the same as adult insects. Of the larvæ which undergo a complete transformation, some kinds, as maggots, have no legs; others have a pair of legs to each of the three first segments; others have a pair to each of the three first segments, and, besides these, several fleshy legs placed beneath the abdominal segments, and known as prop-legs.

FIG. 379.



"Measure-worm"—Larva of a Geometrid Moth, with two pair of prop-legs.

Insects proper may be divided into seven groups or Sub-orders, thus:

1. HYMENOPTERA or Membrane-winged Insects; with four membranous wings traversed by a few irregularly branching veins; four jaws, the upper pair horny, and the lower longer and softer; as Bees, Wasps, Ichneumons, Saw-flies, etc.
2. LEPIDOPTERA or Scaly-winged Insects; with four wings covered with scales which are easily removed; and with a tongue formed of two grooved threads placed side by side so as to make a sucking organ; as Butterflies and Moths.
3. DIPTERA or Two-winged Insects; with only two real wings, the hind pair being represented by two knobbed threads or bal-

ancers; and with a mouth formed for sucking or lapping; as Flies, Musquitoes, etc.

4. COLEOPTERA or Sheath-winged Insects; with the upper or forward wings horny, and the under or hind wings larger and membranous; and with two pairs of jaws for biting; as Beetles.
5. HEMIPTERA or Bugs, Cicadas, etc.; with four wings, in most cases; and with the mouth-parts in the form of a beak consisting of a horny sheath containing three intensely sharp bristles; Cicadas, Plant-lice, Bugs, etc.
6. ORTHOPTERA or Straight-winged Insects; with the forward wings somewhat thick, and generally lying straight along the top or sides of the back, and the under ones thinner, larger, and folded in plaits like a fan; and the mouth-parts adapted for biting; as Grasshoppers, Locusts, Crickets, etc.
7. NEUROPTERA or Nerve-winged Insects; with four membranous net-veined wings, the hinder ones, in most cases, the larger; and with jaws suited for biting; as Dragon-flies, May-flies, Ant-lions, etc.

It must be stated here that many naturalists regard these groups as real orders instead of sub-orders; and they stand as orders in many books which the student and reader may have occasion to consult on this subject.

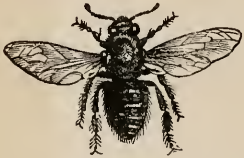
These Sub-orders will now be briefly considered and illustrated.

1. THE SUB-ORDER OF HYMENOPTERA. These insects, as already indicated, have four membranous wings, the hind pair the smaller, and all traversed by a comparatively few veins. Hymenopters have four jaws, the upper pair fitted for biting, and the lower pair the longer and softer, and, with the lower lip, adapted for collecting honey, in many cases. The females are provided with stings, but the males have no weapons excepting their jaws. In passing from the egg state to the imago state they undergo a complete transformation.

The name Hymenoptera comes from the Greek *humen*, a membrane, and *pteron*, a wing. To this Sub-order belong the Bees, Wasps, Ants, Ichneumons, Gall-flies, Saw-flies, etc.

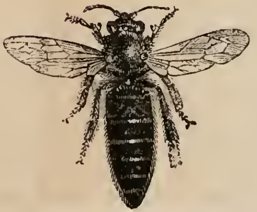
In general, Bees or Apidæ are social in their habits, and the species are composed of three sorts of individuals—*females* or *queens*, *males* or *drones*, and *imperfectly developed females* or *workers*; the last are smaller than the others, and are often improperly called *neuters*.

Fig. 380.



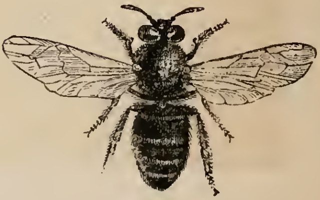
Worker.

Fig. 381.



Queen.

Fig. 382.

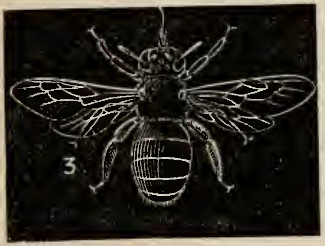


Drone or Male.

Hive Bee, *Apis mellifica.*

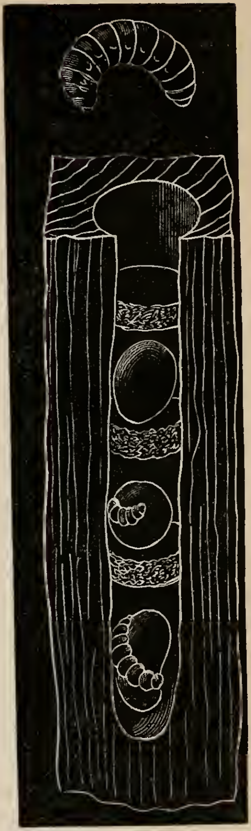
The Humble-bees (*Bombus*) are relatively of large size, and their bodies are hirsute. They live in small communities, which arise from a single female which has survived the winter. Some kinds of bees—"Carpenters," etc.—are solitary. The Carpenter-bees (*Xylocopa*) are of large size, and they form a tube or burrow in wood, and deposit therein their eggs, arranging them in successive layers in masses of pollen (Fig. 384). And the Leaf-cutters (*Megachile*) are bees which cut pieces from leaves and with them make a honey-tight cell. The Mason Bees (*Osmia*) are bluish, or green, smooth and shiny, and they build their nests of sand in stems of plants, and in crevices.

FIG. 383.



Carpenter Bee, *Xylocopa*.

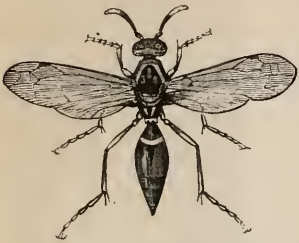
FIG. 384.



Nest of the Carpenter Bee, *Xylocopa*; and the Bee in the larva state.

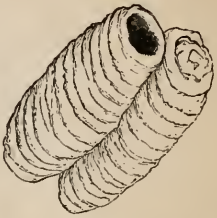
The Wasps or Vespidæ also live in communities composed of females, males, and workers. They construct complex nests underground, or attached to overhanging rocks, to trees, fences, or buildings. These nests consist of tiers of hexagonal cells with their mouths downward, and supported by pedicels; and the çells in a single nest, in some cases, number sixteen thousand. These representatives of the Hymenoptera are especially interesting as being the first paper-makers! Their nests are made of a paper-like substance, which is wood reduced to a paste by the action of the jaws of these insects. The Wasp communities are also dissolved on the approach of winter; and each female that survives the winter founds a new colony the ensuing spring.

Fig. 385.



Wasp, *Polistes pallipes*, Lapel.

Fig. 386.



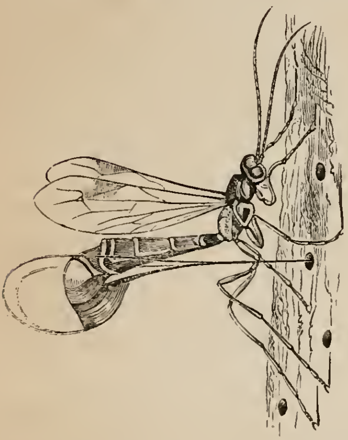
Mud-cells or nest of the Mud-wasp.

Some kinds of Wasps, however, are solitary in their habits; this is true of the Mud-wasps, which build their nests of mud (Fig. 386), and store them with spiders and other insects, for their larvæ to feed upon.

The Ants or Formicidæ are hymenoptera, which also live in communities composed of females, males, and workers; the two first are furnished with loosely-attached wings, and the last are destitute of wings. The workers have the care of the nest and of the rearing of the young; they go in search of food, feed the larvæ, take them into the sunshine in fine weather, and back again into the nest at night or when bad weather comes, and watch over them with a wonderful fidelity. Most ant-hill communities are composed of individuals of one and the same species; but in some cases the workers procure auxiliaries by visiting the ant-hills of other species, and forcibly taking the larvæ and pupæ and bringing them to their own nest, and there having them reared and trained to work for the community in which they are reared!

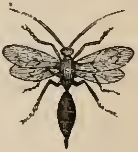
The Ichneumons or Ichneumonidæ have the body long and narrow, the antennæ long, the ovipositor generally long and protected by two thread-like organs of the same length as the ovipositor itself. Ichneumons deposit their eggs in the eggs, larvæ, and pupæ of other insects; and upon these the ichneumon larva feeds when hatched.

Fig. 387.



Ichneumon, *Pimpla lunator*, Fabr., ovipositing in holes bored by Tremex.

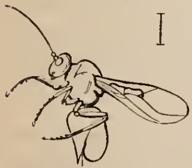
Fig. 388.



Ichneumon, I. *surturalis*, Say.

Among the interesting members of the Hymenoptera are the Gall-flies or Cynipidæ. By puncturing a species of oak growing in Western Asia, Gall-flies produce the nut-galls of commerce, and these supply the world with ink. The Gall-flies have the head short and broad, the thorax thick and oval, and the abdomen much compressed and attached to the thorax by a very short pedicel. They are very numerous, and the different kinds attack different kinds of plants.

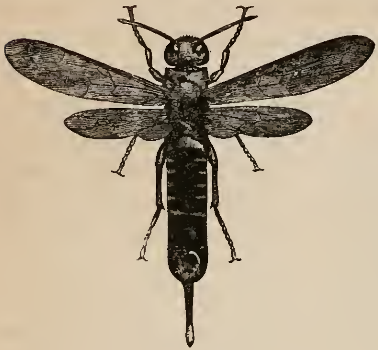
Fig. 389.



Rose-bush Gall-fly, *Rhodites dichlocerus*, Harris.

Among the largest of the Hymenoptera are the Boring Saw-flies known as "Horntails," which have the body nearly cylindrical, and the blunt abdomen ending in a horny point. Beneath this abdomen they have a long saw-like and powerful borer, with which they bore holes into trees, in which they deposit their eggs. Their larvæ belong to the great host of tree-borers.

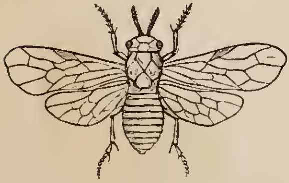
Fig. 390.



Boring Saw-fly or Horntail, *Tremex columba* of authors.

There are other saw-flies (Fig. 391) belonging to the Hymenoptera, which are included in a separate family—the Tenthredinidæ. These Saw-flies are of various species, some of which attack the Rose, others the Vine, others the Elm, others the Fir-tree, etc. All have an ovipositor consisting of double saws lodged under the body and covered by two pieces as a sheath. They are sluggish in their habits. Their larvæ have from eighteen to twenty-two legs, and are found in communities on the leaves of birch and alder, holding fast by their true legs, while the rest of the body is curved upward.

Fig. 391.



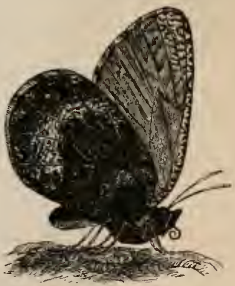
Fir-tree Saw-fly enlarged, *Lophyrus abietis*, Harris.

2. The Sub-order of Lepidoptera is composed of insects which have four wings covered with scales that are easily removed. The name is derived from the Greek

lepis, a scale, and *pteron*, a wing. The Lepidoptera have a tongue consisting of two grooved threads placed side by side, so that the grooved sides come together and form a channel by their junction, and thus the tongue is adapted for sucking purposes; and accordingly these insects drink the dew and feed upon the honey of flowers. When not in use, this tongue is rolled up like a watch-spring beneath the head, and more or less concealed on each side by an organ called a palpus. The legs of the Lepidopters are six in number, but the forward pair is short, and sometimes rudimentary, or wanting. In the larva state these insects are called caterpillars, and they have from ten to sixteen legs. Most kinds of caterpillars feed upon plants. Some kinds eat the leaves, others the blossoms, others the seeds, others the stems, and others the roots. Some kinds of caterpillars, however, eat fabrics, furs, feathers, leather, meat, lard, and even wax. In coming to their full growth as larvæ they usually change their skin four times.

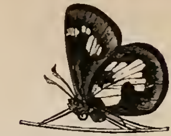
The Lepidopters include the Butterflies and the Moths. The former are readily distinguished by their knobbed antennæ (Fig. 395), and by the fact that they hold their wings erect when they alight. The Moths have variously formed, but never knobbed, antennæ, and their wings are sloping when they alight. All of the Lepidopters pass through a complete transformation in coming to maturity. Many of the caterpillars of the Moths spin cocoons; many, however, do not; and none of the caterpillars of the Butterflies spin cocoons.

FIG. 392.



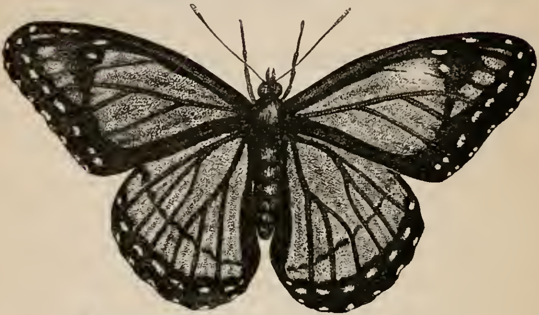
Mountain Butterfly, *Chionobas semidea*, Edwards.

Fig, 393.



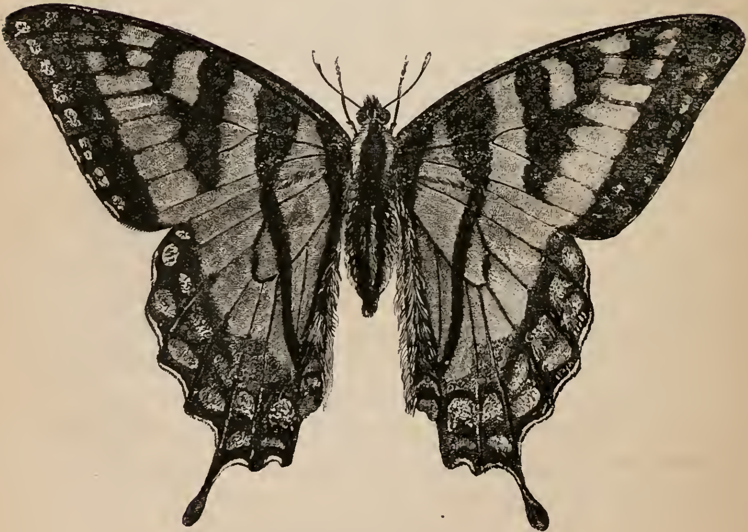
Skipper Butterfly, *Hesperia.*

Fig. 394.



Misippus Butterfly, *Limenitis Misippus*, Godart.

Fig. 395.

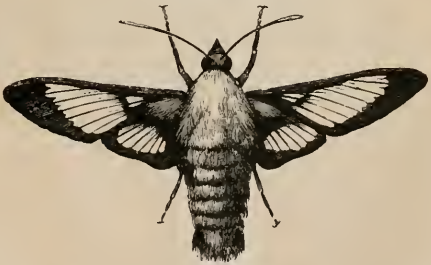


Turnus Butterfly, *Papilio turnus*, Linn.

The Butterflies of North America are numerous, and many of them are exceedingly beautiful, as any one may see by examining them, or the splendidly illustrated works of Edwards, and those of Scudder, as well as the illustrations of our butterflies in foreign works. A few of the common forms are shown in Figs. 392–395.

Of the Moths we have room only to mention the Sphinges or Hawk-Moths, and a few of the broad-winged moths. The Hawk-Moths or Sphingidæ are mostly very large lepidopters, and the wings are long and comparatively narrow. These moths fly with great rapidity, and with few exceptions they visit the flowers to secure honey in the morning and evening twilight; and as they balance themselves before the petunias and other flowers, by the rapid movements of their wings, they may easily be mistaken for humming-birds. Their tongue is exceedingly long—in some cases five or six inches (Fig. 399). The caterpillars of these moths are very large, and they assume curious attitudes. Supporting themselves on their hind legs, they elevate the forward part of the body, and remain for hours in this sphinx-like position (Fig. 397).

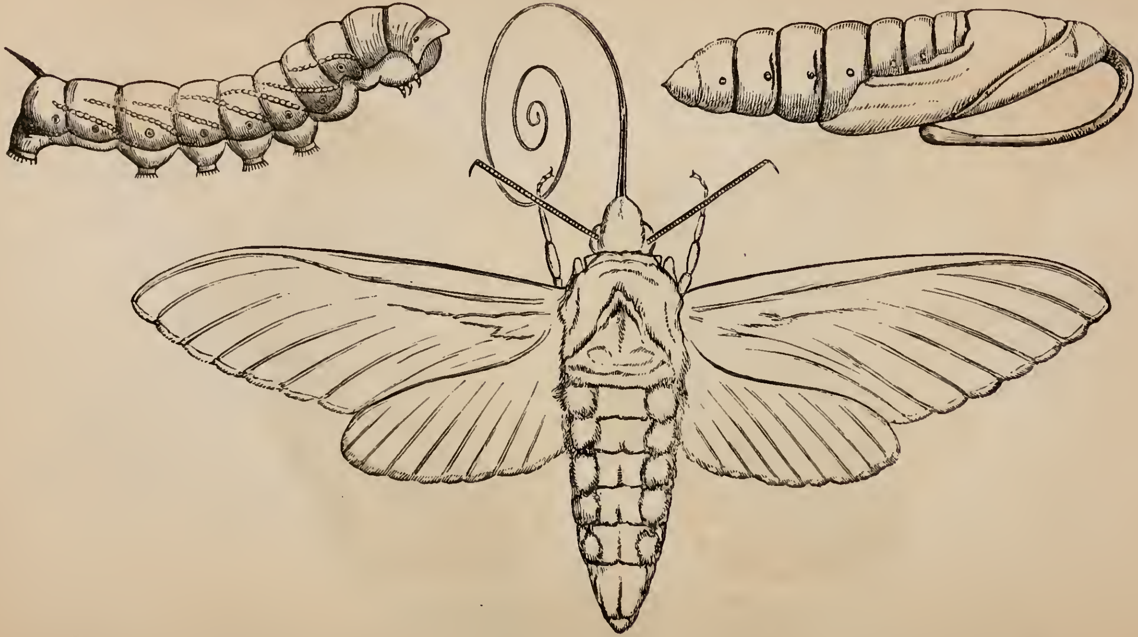
FIG. 396.



Clear-winged Sphinx, *Sesia thysbe*, Fabricius.

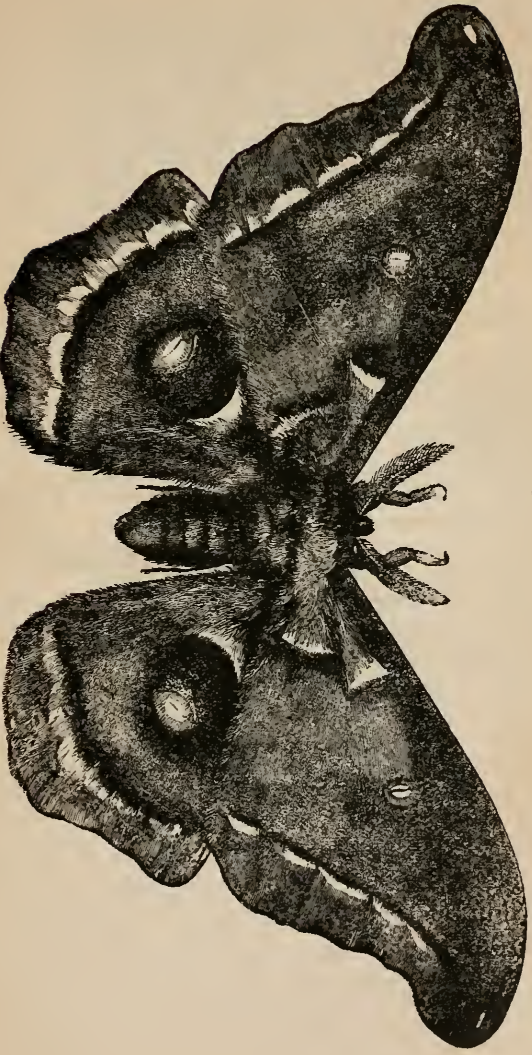
Some kinds of sphinges—as *Sesia*—have their wings transparent.

Fig. 397. Fig. 399. Fig. 398.



Hawk-Moth or Five-spotted Sphinx, *Sphinx quinquemaculatus* of authors. Fig. 397, Larva; Fig. 398, Pupa; Fig. 399, Imago.

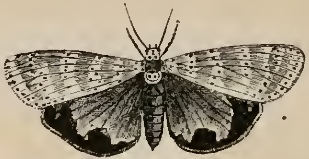
Fig. 400.



American Silk-worm Moth, or Polyphemus Moth, *Telea polyphemus*, Fabricius.
(For Larva and Cocoon, see Figs. 370 and 377).

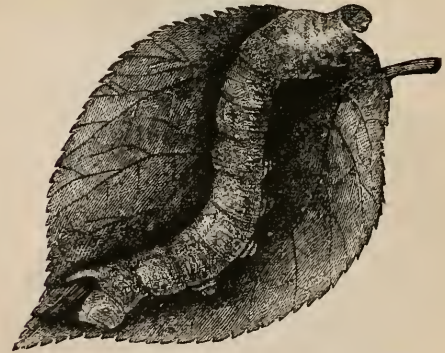
Some of the broad-winged or Silk-worm Moths or Bombycidæ, as *Cecropia*, *Promethea*, *Polyphemus* (Fig. 400), *Luna*, Regal Walnut Moth, etc., are remarkable for their large size; others, as the beautiful *Deïopeia* and the Wood-Nymphs (*Eudryas*), are remarkable for their beauty; and all in the larva state spin silken cocoons, in which they pass into the pupa state. One species, the "Silk-worm" (Figs. 402–3), produces the greater part of the silk used in the world. One of the most common of the small broad-winged moths, is the Tent-caterpillar Moth, which in the larva state lives upon neglected apple trees, and upon wild-cherry trees, and spins the well known tent-like nests.

FIG. 401.



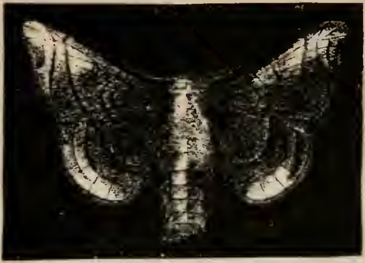
Beautiful Deïopeia, *Deïopeia bella*, Drury.

FIG. 402.



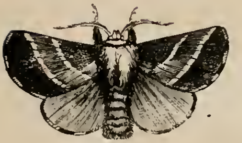
Silk-worm Moth, *Bombyx mori*, in the larva state.

FIG. 403.



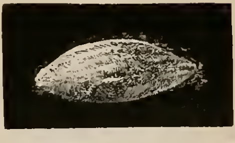
Silk-worm Moth, *Bombyx mori.*

FIG. 404.



Tent-Caterpillar Moth, *Clisiocampa americana,* Harris.

FIG. 405.



Cocoon of Tent-Caterpillar, *C. americana,* Harris.

3. THE SUB-ORDER OF DIPTERA is so named from the fact that the insects of this group have only two real wings, the place of the hind wings being supplied by two knobbed threads called balancers, as seen in Figs. 406, 410. The name is from the Greek *dis*, two, and *pteron*, a wing. The mouth of the Diptera is modified for either sucking or lapping. The sucker or proboscis is composed of two to six bristle-like organs, in some cases sharper than the sharpest needles, and either inclosed in the groove of a sheath terminated by two lips, or covered by one or two laminæ which serve the purpose of a sheath.

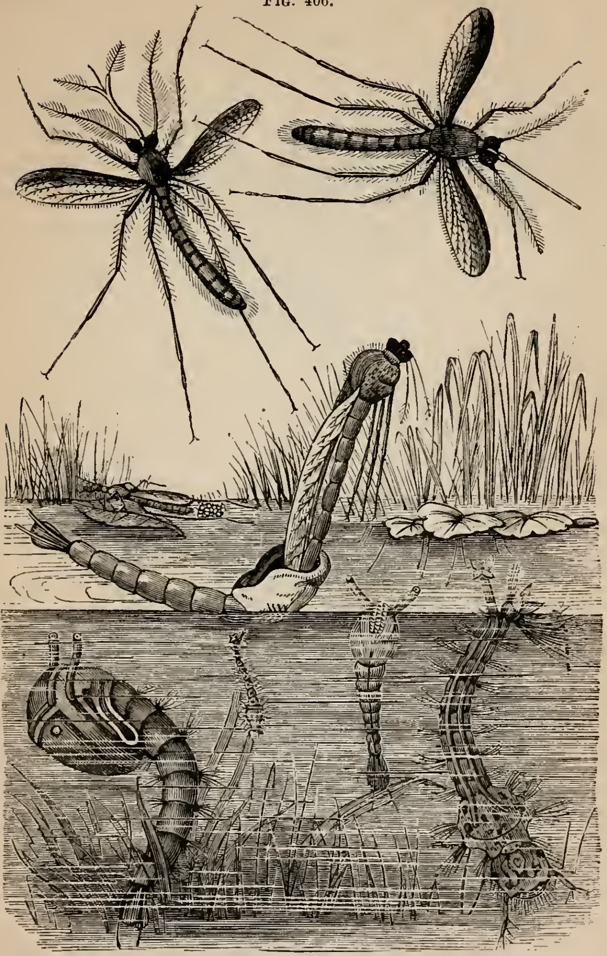
The Dipters undergo a complete transformation in coming to maturity. Their larvæ are without feet, and are called maggots. The pupæ in most cases are inclosed in the dried skin of the larvæ. Some kinds of dipters, as

Gnats or Musquitoes, lay their eggs in the water, and their larvæ may be seen in summer in all stagnant pools, where they are popularly known as "wrigglers." They rest with their head downward, and the hind extremity, which contains the respiratory organs, is at such times at the surface of the water. They are very active, and move with a wriggling motion through the water, but come to the surface from time to time to secure air through their respiratory organs. At the end of their larval state they shed their skin, but still remain in the water, and move by means of their hind-body; but now they assume a different attitude, and the respiration is carried on through two tubes situated on the thorax. At the end of the pupa state, which lasts only a few days, the skin splits upon the back, between the breathing-tubes, and the winged insect or imago appears, and after resting awhile on its empty pupa-case as it floats upon the water, it flies away in search of a victim whom it may pierce for blood. These kinds of dipters discharge a poisonous fluid into the wounds which they inflict, and this is the cause of the irritation which follows their attacks.

The larvæ of some species of the Diptera, as the Hessian Fly (Fig. 410) and the Wheat-fly (*Cecidomyia tritici*, Kirby), are very injurious to the farmer, sometimes destroying whole wheat-fields.

Several species of the Diptera are very injurious or annoying to cattle and horses. One of these is known as the Black Horse-fly (*Tabanus atratus*, Fabricius), another as the Orange-belted Horse-fly (*T. cinctus*, Fabr.), and another the Lined Horse-fly (*T. lineola*, Fabr.). All of these have the eyes very large, covering nearly the whole head, and they have a proboscis inclosing six sharp lancets in the female, and four in the male.

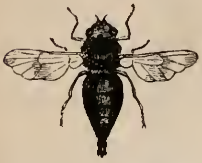
FIG. 406.



Gnats or Musquitoes (*Culex pipiens*) in various stages of development.

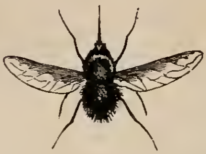
Other members of the Diptera, as the Asilus Flies (Fig. 411), are very long-bodied, and very destructive, in their larva state, to the roots of plants, and in the adult state are very rapacious, seizing and destroying other insects.

Fig. 407.



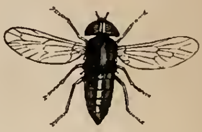
Bot-fly, *Gasterophilus equi*, Linn.

Fig. 408.



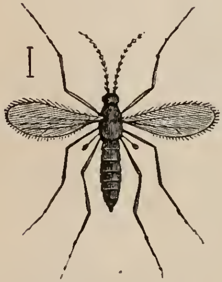
Bee-fly, *Bombylius æqualis*, Fabr.

Fig. 409.



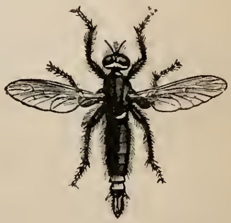
Horse-fly, *Tabanus lineola*, Fabr.

Fig. 410.



Hessian Fly, *Cecidomyia destructor*, Say.

Fig. 411.

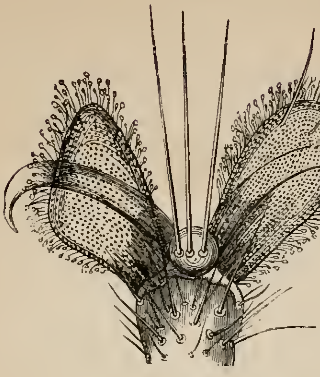


Asilus, *Asilus æstuans*, Linn.

Some of the forms of the Diptera.

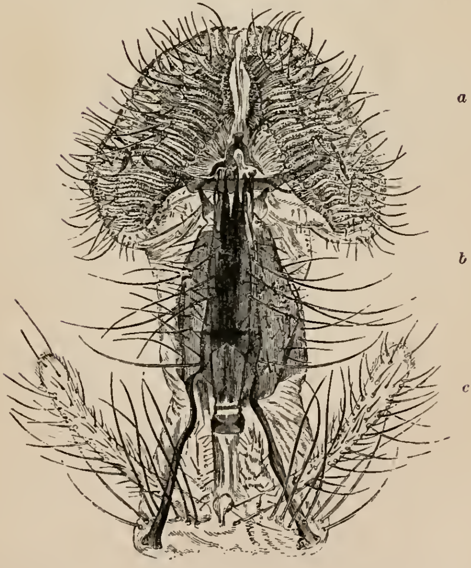
Other dipters still are the Bot-flies (*Œstridæ*), which in the larva state inhabit various parts of the body of herbivorous animals, as horses, cattle, sheep, etc. These flies (Fig. 407) have very short antennæ, large head, and the wings covering the balancers; and the hind-body of the females has a conical tube bent under the body, and with it they lay their eggs when flying. By biting the parts where the eggs are laid, the horse gets them into his mouth and swallows them. The larvæ, by means of hooks, cling to the walls of the stomach till they come to the end of their larval life. Another species (*Œstrus*

FIG. 412.



Foot of a Fly.

FIG. 413.



Tongue of the common Fly. *a*, lobes of the ligula ; *b*, portions inclosing the lancets ; *c*, maxillary palpi.

bovis, Fabr.) lays her eggs on the backs of the cattle, and the larvæ penetrate the skin and live there in open sores. Another species (*Cephalomyia ovis*, Linn.) lays her eggs in the nostrils of sheep, and the larvæ crawl into the cavities of the head, and in many cases produce death.

But by far the largest group of all the Diptera is that which Latreille called the Muscidæ, which includes about one-third of all the members of this sub-order, and which are known under the popular names of House-flies, Flesh-flies, Blow-flies, Cheese-flies, etc.* Meigen has already, a long time ago, described 1,700 species of these flies as belonging to Europe, and there is probably even a greater number in this country. These flies have a wonderful power of reproduction. Some species, as the Flesh-flies, are viviparous. Réaumur found 2,000 larvæ in a single specimen of this sort.

Among the Diptera there are some anomalous forms. One of these is seen in the Fleas or Pulicidæ, which are wingless flies with hard, compressed bodies, with two simple eyes instead of compound eyes, a sucker-like arrangement of mouth-parts, and hind legs specially adapted for leaping. By many writers the Fleas are regarded as constituting a distinct order called the APHANIPTERA, from the Greek *aphanizo* to hide, and *pteron* a wing.

Other anomalous forms are seen in the Horse-ticks (*Hippobosca*), Sheep-ticks (*Mellophaga*), Bird-ticks (*Ornithomyia*), etc. These have a horny, flattened body, flat head, large eyes, rudimentary antennæ, and a proboscis formed by the labrum and maxillæ. They are parasites, and differ from all other insects in their mode of development. Each female produces only one or two larvæ, and when first hatched the larva is not divided into rings, but is smooth and egg-like, the whole covering being a puparium-like case in which the larva becomes a pupa immediately after it is born.

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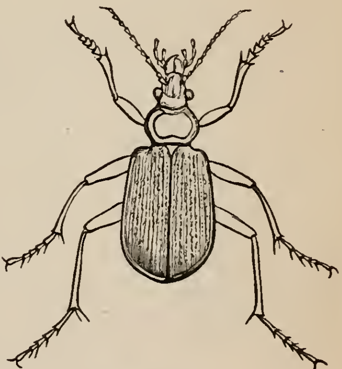
* For a full account of the House-Fly, see Packard "On the Transformations of the House-Fly."

The spider-shaped Bat-ticks or Nycteribidæ, which are parasites on the Bat, and the Bee-lice (*Braulina*), minute, wingless, blind insects, parasites on Bees, are other anomalous forms of the Diptera.

4. The Sub-order of Coleoptera. The Coleoptera or Beetles are insects whose upper or anterior wings, called elytra, are more or less horny, and meet in a straight line upon the top of the back; and in general there is a small triangular piece, called the scutellum, between their bases. Their hind or under wings are thin, and when not in use are folded longitudinally and transversely. The Coleoptera have two pairs of jaws, which move sidewise, and the larvæ, which are called grubs, undergo a complete transformation in coming to maturity. There are probably more than 100,000 species of Beetles, and they present a great diversity of form, size, color, structure, and habits. The name Coleoptera is from the Greek *koleos*, a sheath, and *pteron*, a wing.

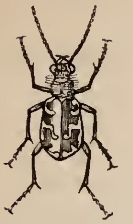
Fig. 414.



A Beetle, Caterpillar-Hunter, *Calosoma scrutator*, Fabricius.

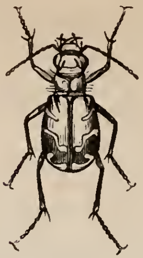
Some kinds, as the Tiger Beetles or Cicindelidæ, have a large head, long antennæ, and toothed mandibles, and are very rapacious in their habits. Their larvæ are provided with powerful jaws, and are also rapacious. The larvæ

FIG. 415.



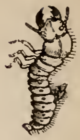
Tiger-Beetle, *Cicindela hirticollis*, Say.

FIG. 416.



Tiger-Beetle, *Cicindela vulgaris*, Say.

FIG. 417.



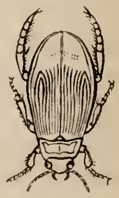
Tiger-Beetle Larva.

dig vertical holes in the ground, in which they remain, the head just fitting the entrance, and when any insect passes near enough they seize it and devour it.

The Predaceous Ground Beetles or Carabidæ are also rapacious, and are known as Caterpillar Hunters (Fig. 414).

The Dytiscidæ are fitted for a residence in the water, and these have their hind legs specially fitted for swimming. They are also exceedingly rapacious, both in the larva and in the adult state, devouring all kinds of small aquatic animals, even fishes.

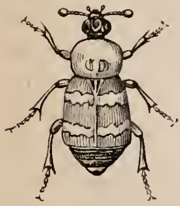
FIG. 418.



Water-Beetle, *Dytiscus*.

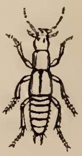
The Gyrindæ are found moving in all sorts of curves and gyrations on the smooth surface of standing waters; and these too swim by means of the fringed hind legs.

FIG. 419.



Carrion-Beetle, *Silpha*.

FIG. 420.



Rove-Beetle, *Staphylinus*.

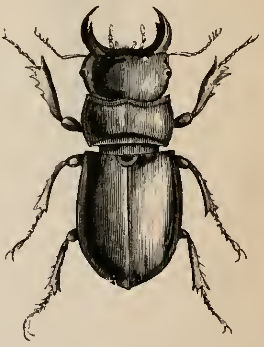
Some kinds, as the Carrion Beetles or Silphidæ, are true scavengers. Living together in great numbers, they perform a most useful service in removing noxious substances. Some species of this family have the habit of burying all the small dead animals which they find. They dig beneath the animal till they sink it out of sight, then deposit their eggs in it; and as soon as the young hatch, the latter begin to devour it, and thus the noxious substance is soon converted into living tissues.

The Rove-Beetles are long and narrow, and the abdomen is much longer than the elytra. When touched, or when they run, they elevate the abdomen and flex it in every direction.

The Dermestidæ are small beetles which, in the larva state, attack skins and all parts of dried animals. They often commit great havoc in zoölogical collections.

The Horn-bugs or Lucanidæ are beetles whose head is very large and broad, and whose upper jaws are very large, and often branched. In the grub state they live in the roots and trunks of trees, and some of the species are six years in coming to maturity!

FIG. 421.

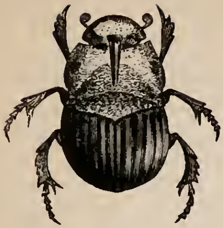


Horn-Bug, *Lucanus dama*, Fabr.

Of all the groups of the Coleoptera, the Scarabæans or Scarabæidæ are one of the most extensive. Here belong the May-Beetle, Rose-Chafers, Goldsmith Beetles, and a host of others. They differ from one another in many important respects, but agree in having a rather short convex form, the antennæ ending in a knob composed of three or more leaf-like pieces, a visor-like piece which extends forward over the face, and their legs fitted for digging (Figs. 422–3).

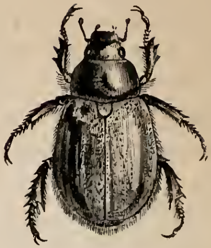
The Buprestians or Buprestidæ are beetles which have the head apparently sunk into the thorax nearly up to

FIG. 422.



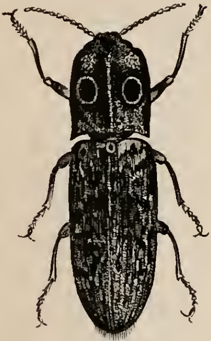
Scarabæian, *Phanæus carnifex.*

FIG. 423.



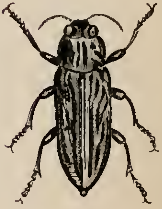
Goldsmith Beetle, *Cotalpa lanigera,* Linn.

FIG. 424.



Spring-Beetle, *Elater oculatus,* Linn.

FIG. 425.



Buprestis, *B. virginica,* Drury.

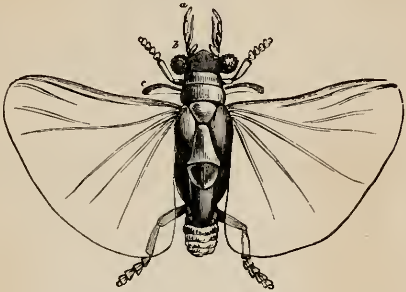
their eyes, and which are very solid. Their lustre is metallic, more or less bronze-like. They are found on trees, and feign death when disturbed. In the larva state they are borers.

The Elaters or Elateridæ have a hard body, and their head sunk, to the eyes, in the thorax, and the latter is as broad as any part of the body. In the larva state they are called wire-worms, and in this state they devour roots and wood. In the adult states they have attracted much attention from their springing upward with a jerk after they have been placed upon the back (Fig. 424).

Some beetles are very important in their relations to pharmacy. The Cantharides or Meloidæ are extensively used for blistering purposes.

The Stylopidæ are minute beetles so apparently abnormal in their appearance and structure that they have by some naturalists been referred to a distinct order called

FIG 426.



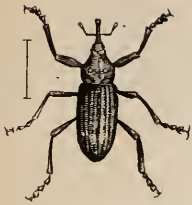
Stylops—male—magnified.

STREPSIPTERA, from *strepsis*, a twisting, and *pteron*, a wing. In the larva state these beetles live as parasites in the body of the bee.

Of the small beetles, none are more destructive than the Weevils or Curculionidæ. Some kinds of weevils attack the pea, others the plum, others grain, others rice, others stored grain, and others the pine, etc. All Curculios are hard-shelled, and the fore part of the head is generally prolonged into a slender snout, at the extremity of which is the mouth armed with small horny jaws. (Figs. 427–9.) In the larva state they are white grubs.

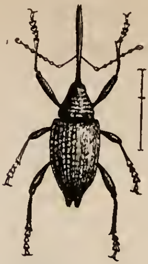
The long-horn Beetles or Cerambycidæ have exceedingly long antennæ. When caught they generally make a squeaking noise. The larvæ are wood-borers, and they are exceedingly destructive. In some species they are

FIG. 427.



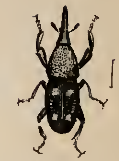
White-Pine Weevil, *Rhynchœnus strobi*, Peck.

FIG. 428.



Long-snouted Nut-Weevil, *R. nasicus*, Say.

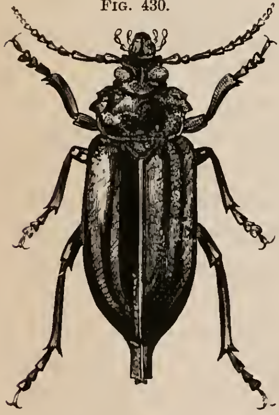
FIG. 429.



Rice Weevil, *Calandra oryzæ*, Linn.

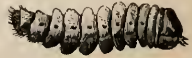
three or more years in coming to maturity as larvæ; they then go into the pupa state in their burrows, and at length appear as adult beetles. To the Long-horns belong the Oak-Pruner (*Stenocorus villosus*, Fabr.), the Beautiful Clytus (*Clytus speciosus*, Say), the Painted Clytus (*Clytus flexuosus*, Fabr.), the Apple-tree Borer (*Saperda bivittata*, Say), etc.

FIG. 430.



"Long-horn," *Prionus laticollis*, Drury.

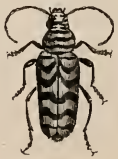
FIG. 431.



Apple-tree Borer, larva, *Saperda bivittata*, Say.

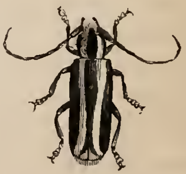
A large number of beautiful golden, and green, and blue beetles are included under the name of Chrysomelidæ. Their

FIG. 432.



Painted Clytus, *Clytus flexuosus*, Fabr.

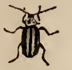
FIG. 433.



Apple-tree Borer, *Saperda bivittata*, Say.

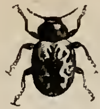
form is hemispherical or oval, the head is sunken, and the antennæ are wide apart. The Cucumber Beetle, the Ladder Beetle (Fig. 435), are examples of this family.

FIG. 434.



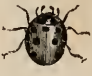
Cucumber Beetle,
Galeruca vittata, Fabr.

FIG. 435.



Ladder Beetle,
Chrysomela scalaris, LeConte.

FIG. 436.



Lady-bug,
Coccinella novemnotata,
Harris.

And lastly, we may notice the Lady-birds or Coccinellidæ as representatives of the Coleoptera. These are small beetles, more or less hemispherical in form, and of a black, red, or yellow color, ornamented with spots. They are rapacious in their habits, both in the larva and in their adult state, devouring plant-lice.

5. THE SUB-ORDER OF HEMIPTERA are insects which have the mouth-parts in the form of a slender horny beak, consisting of a horny sheath inclosing three sharp bristle-like organs, the whole being fitted for a sucking apparatus. When not in use this beak is bent under the body, and lies upon the breast. Bugs, Cicadas, Plant-lice, etc., are familiar examples of this group of insects. The bugs may be regarded as the typical members of the group, as their wings are thick in their basal portion and thin towards their tips; that is, in general terms, half of the wing is of one degree of thickness, and the other half of another degree, and hence the name Hemiptera, from the Greek *hemi*, half, and *pteron*, a wing. As the wings of Bugs thus differ in the two regions, basal and terminal, these insects are often called Hemiptera heteroptera.

On the contrary, other hemiptera, as Cicadas, Plant-lice, etc., have the wings of uniform thickness throughout, and the wings do not lie flat upon the back, as in the Hemiptera heteroptera; and having wings of uniform thickness throughout, they are called Hemiptera homoptera.

Of the Hemiptera homoptera, few, if any, are more interesting than the Cicadas or harvest-flies or Cicadidæ. These insects have a broad head, large eyes, and three eyelets on the crown. Both pairs of wings are transparent and distinctly veined. The males are furnished with an apparatus by which they produce a loud buzzing sound.

This apparatus consists of a pair of organs which have been aptly compared to a pair of kettle-drums—one situated in each side of the abdomen, and each formed of convex pieces of a parchment-like membrane, finely plaited, and played upon by means of muscular fibres fastened to the inside; and thus, by the rapid contraction and relaxation of these fibres, the drum-heads are alternately tightened and loosened, and the sounds above-named produced.

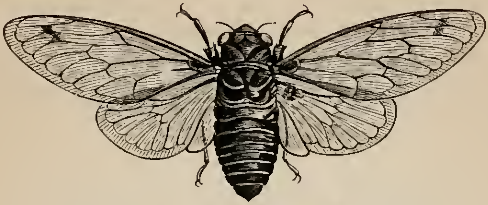
The female Cicadas are provided with a piercer for perforating the limbs of trees, in which they lay their eggs. This piercer consists of three pieces—two outer ones, which are grooved on the inside, and toothed on the outside like a saw, and a central piece, which is a sort of spear-pointed borer, which moves freely between the other two.

The Greeks, we are told, often kept these insects in cages that they might enjoy their "music." And the Greeks also used them as food, eating both the pupæ and the perfect cicadas.

Our common species are the Dog-day Cicada or Harvest-fly (*Cicada canicularis*, Harris) and the seventeen-year

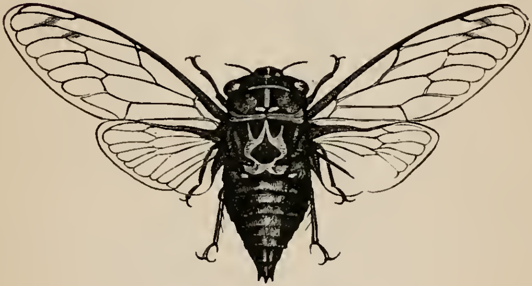
Cicada (*Cicada septendecim*, Linn.), often incorrectly called the Seventeen-year Locust. It is believed that the latter insect appears in the same locality only at intervals of seventeen years, and hence its specific name.

Fig. 437.



Seventeen-year Cicada, *Cicada septendecim*, Linn.

Fig. 438.



Dog-day Harvest-fly, *Cicada canicularis*, Harris.

The Seventeen-year Cicadas come in swarms in the early part of summer, and the forests then resound with their singing from morning till night. The females, in laying their eggs, select small branches and clasp them with their legs, and then repeatedly thrust their piercers obliquely into the bark and wood in the direction of the fibres, and at the same time detaching little splinters of wood at one end, which serve as a fibrous cover to the perforations. After thus forming a fissure, they deposit therein from ten to twenty eggs, which are conveyed to their places by means of the grooved side-pieces of the piercers. When one fissure is filled, another is made and filled, and so on, till each female has deposited her whole stock of four or five hundred eggs. When the eggs hatch, the young fall to the ground and immediately burrow to the roots of the tree, upon whose juices they subsist. They live in this way till the time of their transformation approaches, when they gradually ascend towards the surface, and at length they leave the ground, and crawl up the trunks of trees, where they fix their feet firmly to the bark. After some effort they open a longitudinal fissure in the skin of the back, and through this opening the perfect Cicada comes forth, leaving its dry and empty pupa skin attached to the tree.

Other examples of the Hemiptera homoptera are seen in the strangely-formed little Tree-hoppers or Cercopidæ, which are found upon grass, herbs, and trees, upon the sap of which they subsist, imbibing such quantities that it oozes out of their bodies in the form of little bubbles, covering the insect of the Hemiptera in a mass of froth.

Fig. 439.

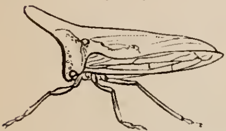
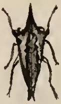


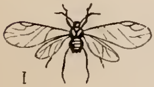
Fig. 440.



Tree-hopper, *Membracis bimaculata*, Fabricius.

Of the very small and minute Hemiptera homoptera, none, perhaps, are more remarkable than the Plant-lice or Aphidæ, and the Bark-lice or Coccidæ. The former have on the hind part of their short body two minute tubes or pores, from which exude minute drops of a sweet fluid. And this fact explains the reason why ants collect in great numbers where Plant-lice abound; for the ants feed upon this honey-like fluid, and the most friendly relations exist between these two kinds of insects. The ants even caress the Plant-lice with their antennæ, apparently soliciting them to give out the sweet fluid!

Fig. 441.



Aphis, *Aphis mali*, Harris.

The Aphidæ multiply with astonishing rapidity, and in this multiplication they admirably illustrate what has been called *Parthenogenesis.*

It is well understood among physiologists that it is the contact of the male sperm-cell with the yolk which fertilizes the egg, and that from the moment of this contact the life of the embryo, which is to be the future animal, begins. This is the general rule among animals in which the sexes are distinct. But among some kinds of the lower animals—as some kinds of Jelly-fishes, Worms, Crustaceans, and Insects—there are exceptions, so that in some species an embryo begins its life without the interposition of the male ; and this mode of reproduction has been called, by Owen, "Parthenogenesis," and by Steenstrup, "alternation of generations," and by Huxley and others, "agamic reproduction." *

For example, the young aphides are hatched in the spring from impregnated eggs laid the previous autumn, and soon they come to maturity, and the whole brood consists of wingless females. These females bring forth living young, each female producing in some cases twenty in a day. These young are also wingless females, and soon they bring forth living young, which are also wingless females, and in their turn bring forth living young. And in this way brood after brood is brought forth, *even to the fourteenth generation, in a single season,* in some cases ; and this, too, without the appearance of a single male. But the latest brood in autumn is composed of both males and females, which have wings ; these pair, stock the plants with eggs, and then perish.

We get some idea of the rapidity of the multiplication of these animals when we remember that Réaumur has proved that a single Plant-louse may become, in five generations, the progenitor of 6,000,000,000 descendants!

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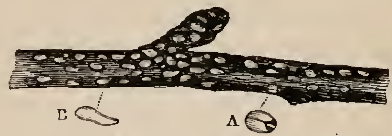
* In the case of one of the highest of the Insects—the Hive Bee—there is something quite different from the ordinary modes of reproduction, and is probably one phase of parthenogenesis. It has been shown by Siebold that the *fertilized* eggs of the queen bee produce either *queens or workers*, according to the conditions to which they are subjected, and the nature of the food given the larvæ ; and that the *unfertilized* eggs produce *drones*, that is males.

Parthenogenesis has been observed even in the *larva* of one insect—a Cecidomyian fly.

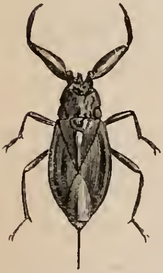
Bark-lice or Coccidæ are very small hemiptera which are found in the form of scales on the bark of trees. The males alone are winged; the females are always in the scale-like form. The Bark-lice are famous for the dyes and other useful materials which they have furnished. The *cochineal* of Mexico, and the *scarlet grain* of Poland, are insects of this family; and species of Bark-lice furnished the famous *kokkos* of the Greeks, the *coccus* of the Romans, the *kermes* of the Arabs, the *cocchi* of the Italians, and the *alkermes* of the Persians.

FIG. 442.



Bark-louse, *Aspidiotus Harrisii*, Walsh. A and B enlarged.

FIG. 443.



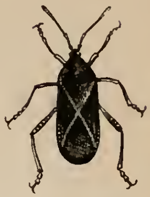
Scorpion-Bug, *Nepa apiculata*, Harris.

Some kinds of hemiptera, as the Boat-flies or Notonectidæ, live in the water, and are noted for their habit of swimming on their backs. Others, as the Scorpion-bugs or Nepidæ, live in the water, and are adapted for seizing prey by their fore legs, which flex upon themselves, and thus act as pincers. Some kinds of scorpion-bugs (Fig. 443) are no more than an inch long; but some species of *Belostoma*, with an oval body, attain a length of three or four inches, and *Ranatra*, with a narrow body, is about three inches in length. Other kinds of hemiptera, as the water-measurers or Hydrometridæ, are found on the surface of water, over the surface of which they move with a gliding motion.

To the Hemiptera belong the little Chinch-bug (*Rhy-*

parochromus), the great wheat-destroyer, and the well-known Squash-bugs (*Coreus*), both of which, by some writers, are referred to one family—Corisiæ. And to this sub-order belong also the minute insects known as the Thripsidæ, which cause the decayed patches on leaves, melons, etc.; and the disgusting Bed-bugs or Cimicidæ; and the Lice or Pediculidæ.

FIG. 444.



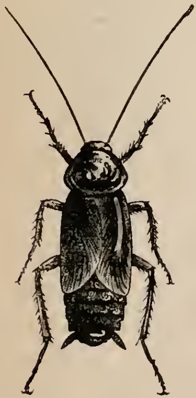
Squash-bug, *Coreus tristis*, DeGeer.

6. THE SUB-ORDER OF ORTHOPTERA.—The name of this group is from the Greek *orthos*, straight, and *pteron*, a wing. The Orthoptera have wings which lie straight along the back, and have their upper wings rather thick, the under ones the larger and thinner, and folded in plaits like a fan. The Orthoptera do not undergo a complete transformation, but they pass by insensible gradations from the larval to the adult stage, all the while remaining active. A few of the leading forms are here enumerated, and some of them illustrated.

The so-called Earwigs or Forficulidæ, have the body armed at the hind extremity with a pair of pointed nippers. The Cockroaches or Blattidæ, have the body broader, flattened, and the hind extremity furnished with conical articulated appendages. The Walking-sticks (Fig. 449) and Walking-leaves, or Phasmidæ, closely resemble twigs and leaves.

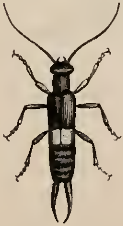
The Mantes or Mantidæ, are much elongated,

FIG. 445.



Cockroach, *Blatta orientalis*, Linn.

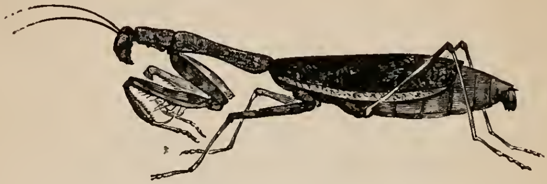
FIG. 446.



Earwig, *Forficula*.

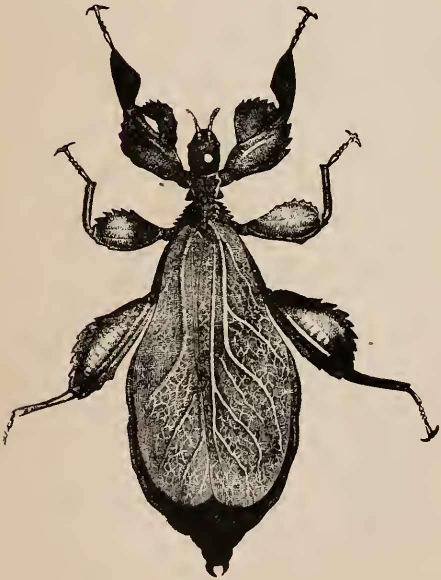
and have the fore legs formed for seizing and holding prey; and they sit for hours holding up their fore legs, ready to seize any insects within their reach.

FIG. 447.



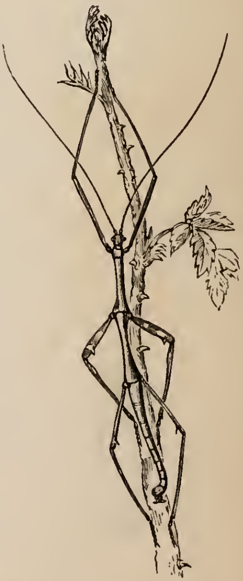
American Mantis, *Mantis carolina* of authors.

FIG. 448.



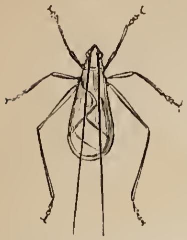
Walking-leaf, *Phyllium siccifolium*.

FIG. 449.



Walking-stick, *Diaphomera femorata*, Scudder.

FIG. 450.

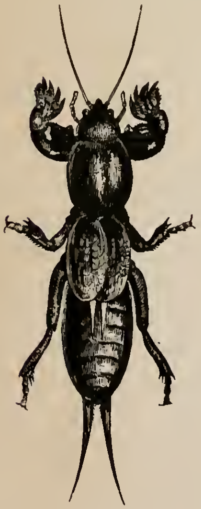


White Climbing-Cricket, *Œcanthus nivæus*, Serv.

The Crickets or Gryllidæ, have an oblong flattened body, long stylets at the hind extremity of the body, and the females are provided with a very long ovipositor for introducing their eggs into the ground; and the males have the membranes and nervures at the base of the wings so specialized that, by the rubbing of the wings upon each other, they can produce a sound known as a *chirrup*.

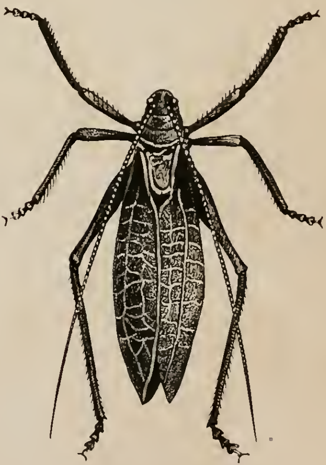
The Locusts or Locustidæ, are grasshopper-like, and have very long antennæ and four-jointed tarsi, and the females have a long ovipositor.

FIG. 451.



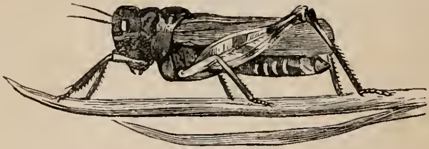
Mole Cricket, *Gryllotalpa borealis*, Burmeister.

FIG. 452.



Katydid, *Cyrlophyllus concavus*, Scudder, The Migratory Locusts—or Acrydii of Latreille—and their allies are orthoptera which have a large head, *short* antennæ, and *three-jointed tarsi*, instead of four-jointed, as in the Locustidæ; and they have no projecting ovipositor. The celebrated Migratory Locusts (*Acrydium*), the Red-legged Locusts (*Caloptenus*), and the Coral-winged, the Yellow-winged, and the Clouded Locusts (*Œdipoda*), and most of the ordinary Grasshoppers, are examples of this family.

FIG. 453.

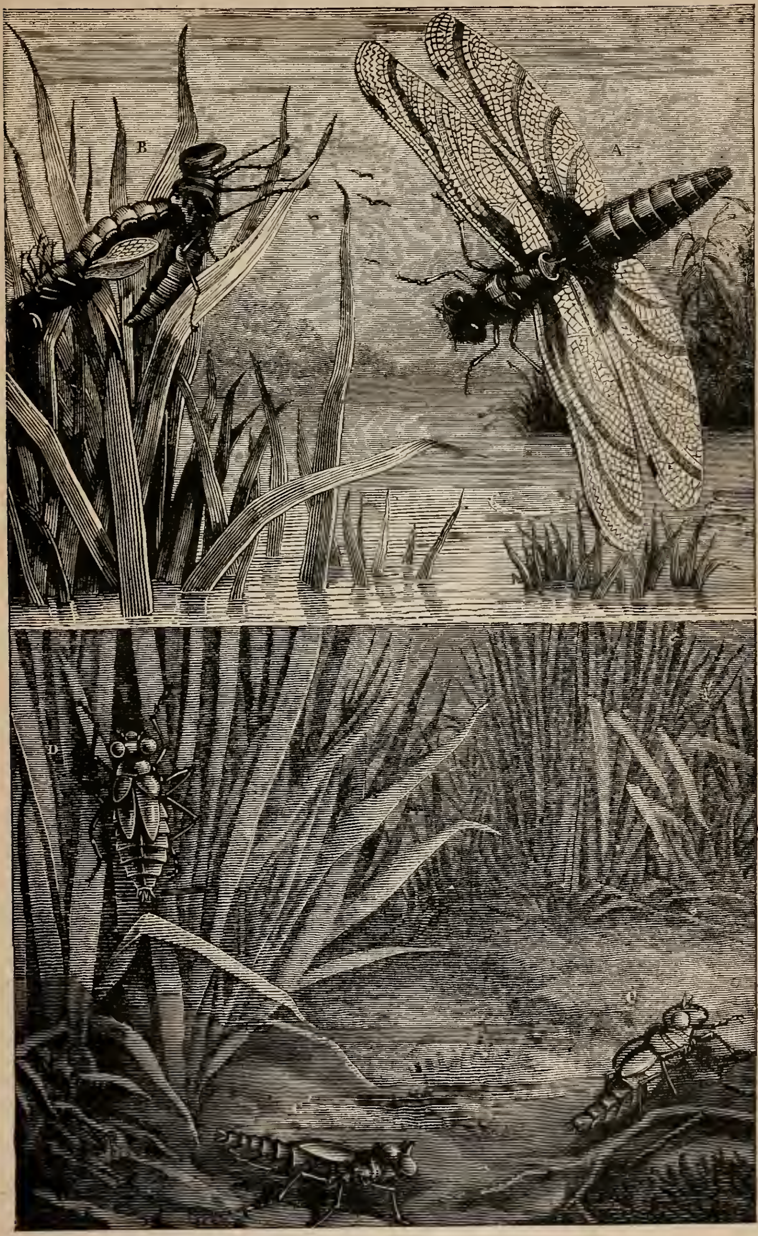


Clouded Locust, *Œdipoda nebulosa*, Erichson.

7. THE SUB-ORDER OF NEUROPTERA is made up of insects well known under the names of White Ants, Stone-flies, May-flies, Dragon-flies, Ant-lions, etc. The name comes from the Greek *neuron*, a nerve, and *pteron*, a wing. The insects of this group have a long body, and four long membranous and finely netted-veined wings, the anterior pair being generally the smaller; very large eyes and large mandibles; and they are destitute of weapons except their jaws. Most of the Neuropters live in the water during the larva and pupa state, and many species do not undergo a complete metamorphosis.

The White Ants or Termitidæ, inhabit only warm countries, and in the larva state feed upon wood, devouring wooden furniture, and even whole houses, as they have done in the Isle of France. The Stone-flies or Perlidæ (Fig. 456), have many-jointed antennæ, and the

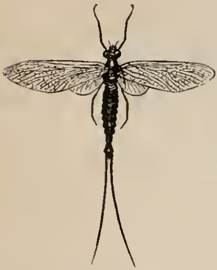
FIG. 454.



Dragon-flies in the Larva, Pupa, and Imago state.

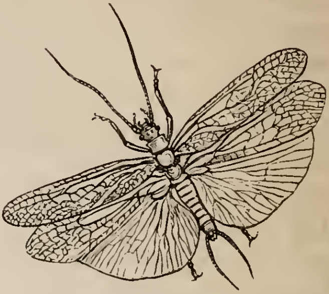
abdomen has two long-jointed appendages. The May-flies or Ephemeridæ (Fig. 455), are very short-lived, living in the imago state scarcely more than a day, although their larva and pupa state extends through several years, all of which they pass in the water.

FIG. 455.



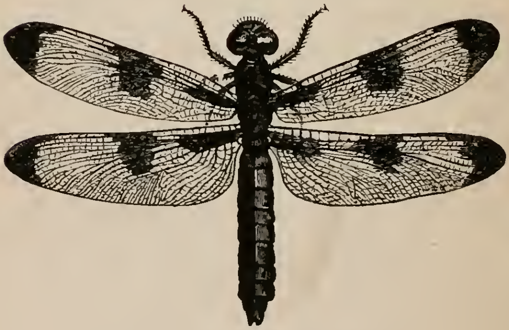
May-Fly, *Ephemera.*

FIG. 456.



Stone-Fly, *Pteronarcys regalis*, Newman.
Much reduced in size.

FIG. 457.



Dragon-Fly, *Libellula trimaculata, DeGeer.*

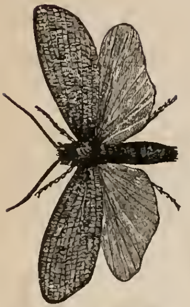
The Dragon-flies or Libellulidæ (Fig. 457), are among the best representatives of the Neuroptera, and have a long body, exceedingly large eyes, powerful jaws, and large and lustrous wings. In the larva and pupa state they live in the water; and when the time comes for them to complete their transformation, they crawl up the stems of plants, and, having withdrawn from the pupa skin, which remains fixed to the plant, and having become dry, they fly swiftly away. At all periods of their life they are exceedingly rapacious, feeding upon all insects which they can capture.

To the Neuroptera also belong the Horned Corydalis (Fig. 460), and its allies or Sialidæ, the Ant-lions (Fig. 461), and other Lace-wings or Hemerobini, and the Caddice-flies or Phryganidæ (Fig. 458).

The Ant-lions are famous for the pitfalls which, while in the larva state, they make in the sands, and at the bottom of which they lie concealed all but the jaws, and there await insects which fall into their pit; these they at once seize and devour.

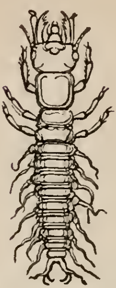
Some kinds of Neuropters are wingless, and are called degradational forms, and closely resemble the Myriapods. Such are the Spring-tails or Thysanura or Poduridæ, which have a cylindrical scaly or hairy body, short and four to six jointed antennæ, four to eight simple eyes on each side, and whose anal bristles are united and bent under the body, forming a sort of spring by means of which these insects leap. Such also are the Bristle-tails or Lepismatidæ, which have a long body covered with silvery-like scales, and the abdomen furnished with three long bristles. They are found among old books and woolens, and also under stones and rubbish in damp situations.

FIG. 458.



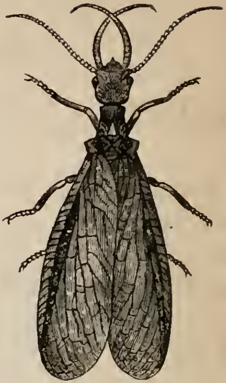
Caddice-fly, *Neuronia fasciata, Say.*

FIG. 459.



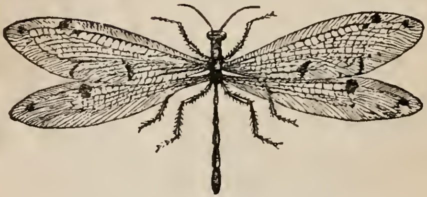
Larva of Horned Corydalis.

FIG. 460.



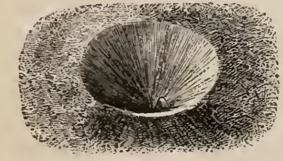
Horned Corydalis, *Corydalis cornuta* of authors. Much reduced in size.

FIG. 461.



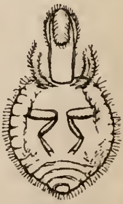
Ant-Lion, *Myrmeleon obsoletus,* Say.

FIG. 462.



Pitfall of Ant-Lion ; tips of jaws exposed.—Reduced.

FIG. 463.



Larva of Ant-Lion.—Enlarged.

SUB-SECTION III.

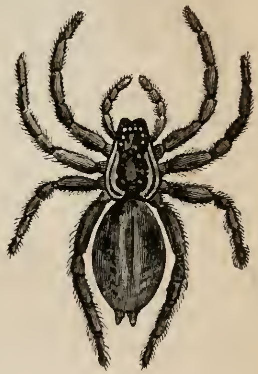
THE ORDER OF ARACHNIDA OR SPIDERS, SCORPIONS, AND MITES.

THE Arachnida are insects which have the body divided into only two well-marked regions—the head and hind body, the head and thorax being closely united in one piece, thereby resembling the cephalo-thorax of the Crustaceans.

As regards their form, they may be said to represent essentially the same idea among Insects that Crustaceans do among Articulates.

Arachnids have simple eyes, and four pairs of legs; they have no antennæ, no wings, and in general they do not change in form after they are hatched from the egg. In coming to maturity they moult their skin six times. The name Arachnida is from the Gr. *arachne*, a spider.

FIG. 464.



An Arachnid—Spider, *Lycosa lenta*, Hentz.

By some writers the Arachnids are regarded as a Class, separate from, and even higher than Insects; but their form and structure seem to show that they are one grade or type of the great group of Insecta, and lower than Insects proper. They are less highly cephalized than typical hexapodous insects.* "We must look upon the Spider as a hexapodous insect degraded, wingless, and partially decephalized."—Packard. They naturally divide into three Sub-orders:

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* *Cephalization*—a term introduced by Professor J. D. Dana—refers to *head-domination*. It refers not only to the head and its structure, but also to "the extent to which the rest of the body directly contributes by its

1. ARANEINA or Spiders proper; with cephalo-thorax and abdomen distinctly marked as two regions, and connected together by a slender pedicel; the abdomen without segments; the palpi or modified maxillæ resembling shorter legs; the mandibles ending in a hook; and the hind part of the body provided with a silk-spinning apparatus.
2. PEDIPALPI or Scorpions; with the abdomen, in the best representatives, distinctly divided into segments; and with the maxillary palpi greatly enlarged.
3. ACARINA or Mites; with the body oval or rounded, and without apparent regions; no wings; no segments, the cephalo-thorax and abdomen being merged into one piece.

1. THE SUB-ORDER OF ARANEINA or Spiders proper, are the best representatives of the Arachnids, and their wonderful structure, and, if possible, still more wonderful habits, have engaged the attention of observers from very early times.

Their body exhibits two well-marked regions, and the more or less oval or rounded abdomen is connected with the cephalo-thorax by a pedicel. The abdomen is not

---

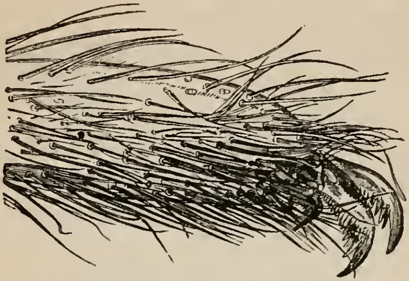
members to the uses or purposes of the head." Professor Dana regards the degree of cephalization as indicating the relative rank of the animal.

Other things being equal, the highest degree of cephalization is exhibited in those species which have the posterior extremity abbreviated—that is, not lengthened out—and the anterior part of the body most compacted, and the parts most completely subservient to the head.

Cephalization reaches its highest expression in Man. The Mammalia as a whole exhibit a high degree of cephalization. The Fishes a low degree. The Carnivora are more highly cephalized than the Herbivora. The Insecta are more highly cephalized than the Crustacea. The Crabs more highly than the Lobsters, Craw-fishes, and Shrimps. And the Cephalopoda and Gasteropoda are more highly cephalized than the Acephela.—See Professor Dana's learned Papers on Cephalization.

divided into rings or segments. The name Araneina is from the Latin *aranea*, a spider.

FIG. 465.



Foot of Spider, magnified.

Spiders have mandibles which end in a strong hook, in the end of which there is an opening to a duct which connects with a poison gland situated in the head. The maxillæ are modified for palpi, and resemble a pair of shorter legs, making the spiders look as if they had ten legs instead of their actual number—eight. In the females the palpi are simple, but in the males the terminal joint is modified so as to be a sexual organ.

Their alimentary canal is remarkable for having in many cases, lateral cæca.

Their circulatory system is quite highly organized. The dorsal vessel is mainly situated in the abdominal region. There is also a ventral vessel with veins or sinuses which act as veins.

The respiratory system of Spiders consists—in most species—of both tracheæ and air sacs or lung-like organs. The latter are small sacs opening by transverse fissures on the under side of the abdomen, near its base, and the inner surface is in the form of lamellæ or plates, each formed by a membranous fold. The tracheæ communicate with the air through openings called stigmata.

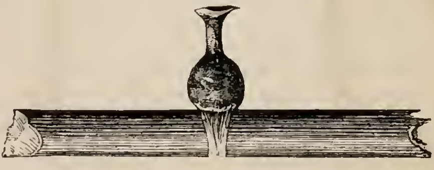
The nervous system consists of a small brain and a mass of thoracic ganglia which connect with more or less developed ganglia in the abdomen.

Most kinds of spiders have eight ocelli; but some kinds have only six, some only two, and certain species which inhabit caves are regarded as blind.

One of the most wonderful parts of the structure of spiders is their silk-spinning apparatus. On the abdominal extremity there are from four to six protuberances, each of which is perforated with a great number of minute holes—in some species as many as a thousand in each protuberance. From these minute holes passes the adhesive fluid or liquid silk, which has its origin in internal reservoirs; and as soon as the fine streams of this material come to the air they harden into silk.

The eggs of Spiders are enclosed in cocoons spun from the same kind of material of which they construct their webs, and the form of the egg-cases or cocoons varies according to the species. The young remain in the cocoon for a long time, and grow there to double the size which they have when hatched, apparently without food.

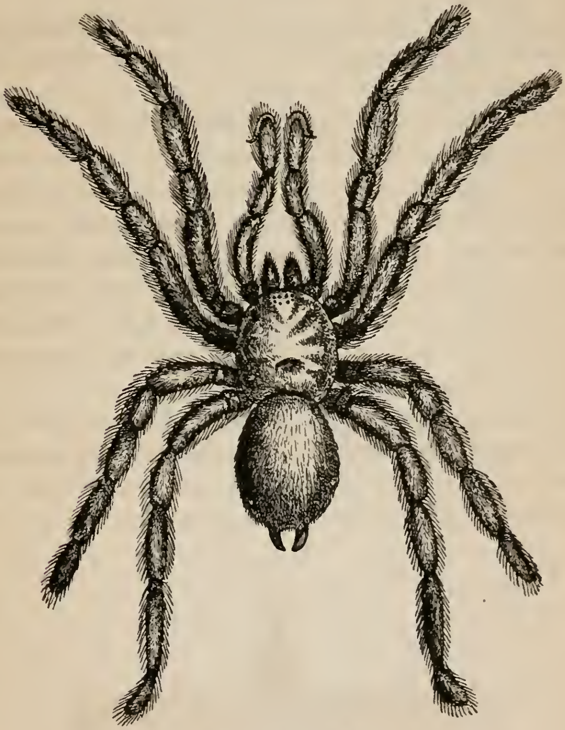
FIG. 466.



Egg-case or Nest of a Spider—"Vase-marker"—found on a grape-vine.

Some kinds (*Mygale*) of spiders have four lung-sacs and four stigmata, and hence Latreille called them Tetrapneumones. They inhabit warm countries, and live in cylindrical holes. The celebrated "Trap-door Spider" is of this division. To their holes or tubes they construct, of silk and earth, a perfectly fitting lid or door, hanging the door with a hinge of silk!

FIG. 467.



Large Hairy Spider, *Mygale Hentzii*.—Missouri and southward.

A vast majority of spiders have only two lung-sacs, and hence are called Dipneumones. These have three pairs of spinnerets. Some kinds (*Clubione*) construct tubes of silk under the bark of trees and under stones. Others, as the Water Spider (*Argyroneta aquatica*, Linn.) of Europe, live under the surface of the water, there making their nest, which is filled with air. Others (*Tegenaria*) make a horizontal web, connected with which is a tubular retreat, where the spider remains till some fly or other insect becomes entangled in the web. Those belonging to the genus *Theridion* have the four inner ocelli larger than the four outer ones, and the first and last pair of legs longest. The genus *Epeïra* includes those which have a large globular abdomen; they are sedentary species, constructing a web formed of spiral threads, and other threads radiating from a center. *Nephila* is a genus of large spiders, which have a long, cylindrical abdomen. *Nephila plumipes* of the Southern States has become celebrated from the interesting experiments made with it by Dr. B. G. Wilder, who, in less than a day wound from it nearly two miles of silk! *Thomisus* includes "wanderers" having very small cheliceres (maxillary palpi). *Dolomedes* includes wanderers which hide under stones, and not unfrequently dive under water, and which make an orbicular cocoon which is carried by the mother. *Lycosa* (Fig. 464), is a genus of large hairy spiders, with large cheliceres, with the fourth pair of feet the longest, and the third pair shortest. The Tarantula belongs to this genus. The genus *Salticus* includes the leaping spiders; they have a large square cephalo-thorax.

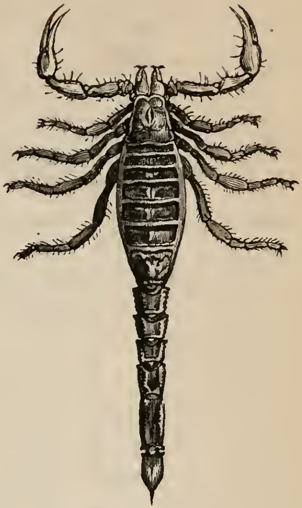
2. The Sub-order of Pedipalpi or Scorpions, and closely allied forms, have the maxillary palpi greatly developed, and in most cases ending in forceps, and their abdomen jointed. It is on account of their jointed abdomen that they are also called Arthrogastra, from the Gr.

arthron, a joint, and *gastēr*, belly.

Some kinds respire by lung-sacs, and some by means of tracheæ. In the true Scorpions—found in warm climates—the hind body is much elongated, and ends in a curved point or sting, which discharges a poisonous fluid into the wounds which it makes.

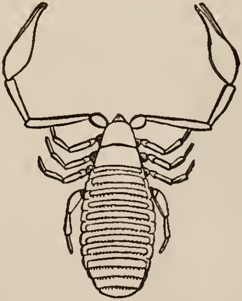
In old books and unused cabinets there are found minute members of this sub-order which have the abdomen rather broad, flattened, eleven-jointed, and without appendages, and their palpi large, and formed like those of the scorpion; these are False-scorpions or Pseudo-scorpions.

FIG. 468.



Scorpion, *Buthus carolinianus*, Beauvois.

FIG. 469.

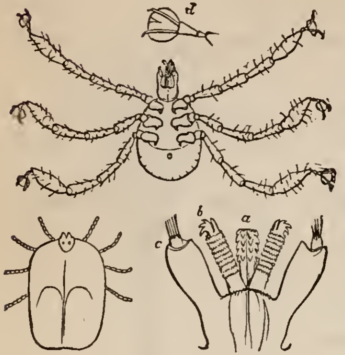


False-scorpion, *Chelifer cancroides*, Linnæus. Enlarged.

To the Pedipalpi belong also the Daddy Long-legs or Phalangidæ; these have the legs *excessively elongated.*

3. The Sub-order of Acarina or Mites, have oval or rounded bodies which exhibit no articulation or divisions into segments, the cephalo-thorax and abdomen being merged together. Most of the species are very minute; a few kinds, however, as the Ticks, attain the length of half an inch. The Red Mites or Trombididæ, are common in the dry warm beds of the garden. The Ticks or Ixodidæ, are large mites with leather-like bodies; they attach themselves to man and animals, especially in warm countries.

Fig. 470.

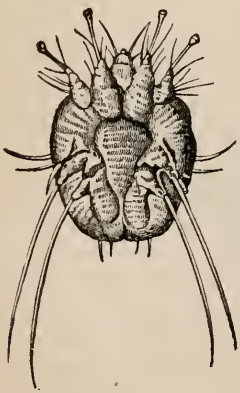


Tick, *Ixodes albipictus*, Packard.

Adult; six-footed young; mouth parts of young; and foot showing claws and sucking disk *d*; *a*, glossoide; *b*, mandibles; *c*, maxillary palpi.

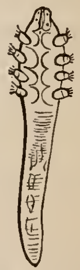
Of the true Mites or Acaridæ, we may mention the

Fig. 471.



Psora or Itch-insect, *Sarcoptes scabiei*, De Geer. Highly magnified.

Fig. 472.



Nose-Mite, *Demodex folliculorum*. Highly magnified.

Sugar-Mite (*Tyroglyphus sachari*), common in unrefined sugar, the Cheese-Mite (*Tyroglyphus siro*), the Flour-Mite (*Tyroglyphus farinæ*), the Itch-Mite (*Sarcoptes scabiei*); the last being the insect which, by burrowing and breeding under the skin, causes the loathsome disease which bears its name; and here also belongs the curious Nose-Mite, which buries itself in the follicles of the human nose.

The last named is perhaps the lowest of the Mites, excepting only certain microscopic worm-like mites found in standing water, and called "Water-bears" or Tardigrada.

SUB-SECTION IV.

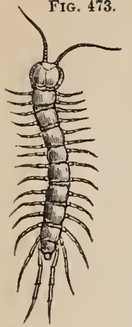
THE ORDER OF MYRIAPODA OR MYRIAPODS.

THE name Myriapoda comes from two Greek words *murios*, numerous, and *pous*, a foot, and is given to insects which are long, and more or less worm-like in their general appearance, and provided with numerous locomotive appendages. Their head is distinctly marked, and similar to that of typical insects. There is, however, no grouping of the segments into regions as in the two orders of insects already noticed. They may perhaps be said to represent, as regards their general form, the same idea among insects that worms do among Articulates.

The number of segments in the Myriapods varies in the different kinds from ten to two hundred. These animals are divided into two Sub-orders:

1. THE SUB-ORDER OF CHILOPODA (from the Greek *cheilos*, a lip, and *pous*, a foot) includes myriapods which have *each segment* simple, and bearing *a single pair of feet*, and which have the head divided into two regions, one before and the other behind the mouth. To

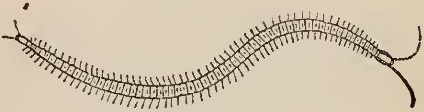
FIG. 473.



Earwig, *Lithobius americanus*, Newport.

this sub-order belong the so-called "Earwigs" or Lithobiidæ, which have a broad and flat head and forty jointed antennæ, and which feed mainly upon earth-worms; the Centipedes or Scolopendridæ, which have from twenty-one to twenty-three feet-bearing segments, and which in some species, as those of the tropics, are six to nine inches long; and the Geophilidæ (Fig. 474), characterized by their slender form, and by their great number of segments, varying in the different kinds from thirty to two hundred.

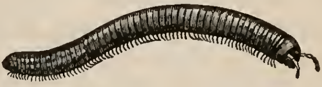
FIG. 474.



Geophilus bipuncticeps, Wood.

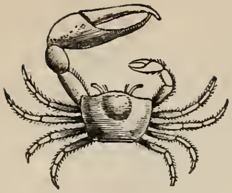
2. THE SUB-ORDER OF CHILOGNATHA is composed of myriapods which have very short and few-jointed antennæ, very numerous segments, and *each segment* provided with *two pairs of feet.* The name comes from the Greek *cheilos*, lip, and *gnathos*, a jaw.

FIG. 475.



"Thousand-legs," *Julus canadensis*, Newport.

To this group belong the "Thousand-legs" or Julidæ, which have the body nearly cylindrical, and made up of nearly equal segments; the Polydesmidæ, which are broad and flat; and the Glomeridæ, which have few segments, and which have the habit of rolling themselves into a ball.



SECTION III.

THE CLASS OF CRUSTACEA OR CRUSTACEANS.

Sub-section I.

The Crustacea Considered as a Class.

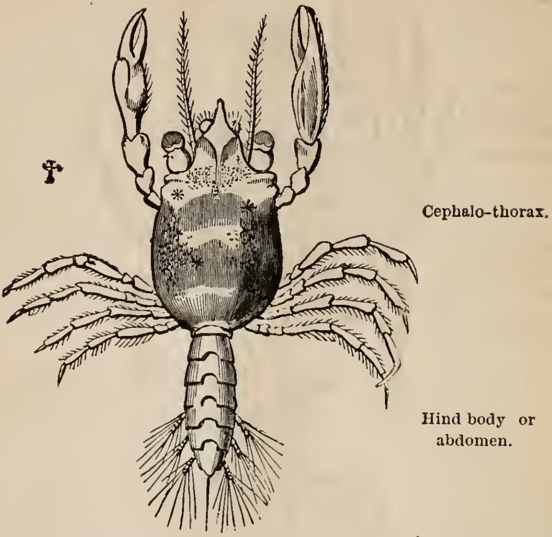
The Crustacea include all articulated animals which are covered with a crust or shell, and which have the head and thorax united into one piece called the *cephalothorax*, and which respire by means of branchiæ or gills. The shell is leathery, horny, or calcareous, and like that of Insects, contains chitine.

Crustaceans are thus aquatic in their mode of respiration, and most kinds live in the water—a vast majority in the ocean; but some kinds live on the land, mainly in damp places.

As examples of this class, we may mention the Crabs (Figs. vignette, 480, 481), Lobsters and Craw-fishes (Figs. 477, 485), Shrimps, Sand-fleas (Fig. 490), Barnacles (Figs. 504, 506), etc.

As already indicated, the head and thorax are so closely united that they appear as one piece or segment, and so the Crustaceans exhibit only two well-marked regions—

FIG. 476.


Cephalo-thorax.
Hind body or abdomen.

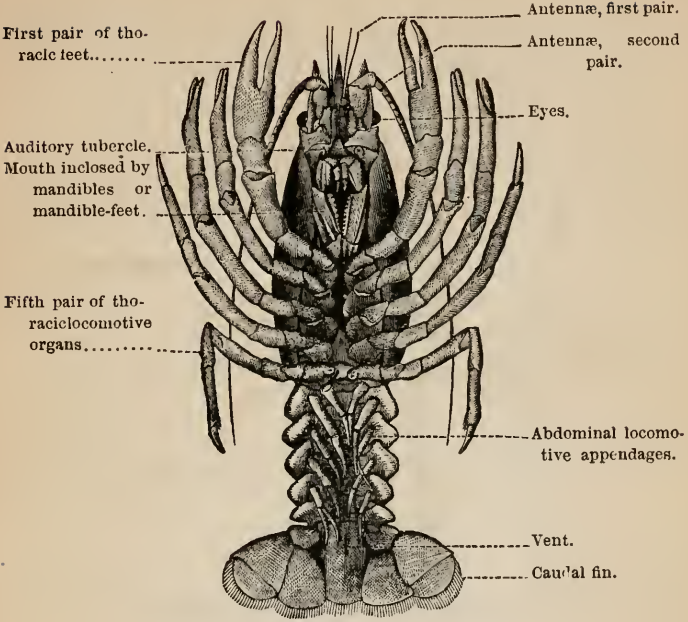
A Crustacean—young Crab magnified. (Natural size indicated by the marks at the left.)

the *cephalo-thorax* and the *abdomen;* only the latter showing distinctly the rings or segments of which it is composed.

Normally, the body of a Crustacean consists of *twenty-one* rings or segments—*fourteen* belonging to the *cephalo-thorax* and *seven* to the *abdomen;* but in the adult state these segments are not apparent in the forward portion of the animal, nor always in the hind portion.

The external appendages of Crustaceans are numerous, and all these appendages have the same fundamental structure, and all are regarded as locomotive organs,

FIG. 477.


Antennæ, first pair.
Antennæ, second pair.
First pair of thoracic feet........
Eyes.
Auditory tubercle.
Mouth inclosed by mandibles or mandible-feet.
Fifth pair of thoraciclocomotive organs.........
Abdominal locomotive appendages.
Vent.
Caudal fin.

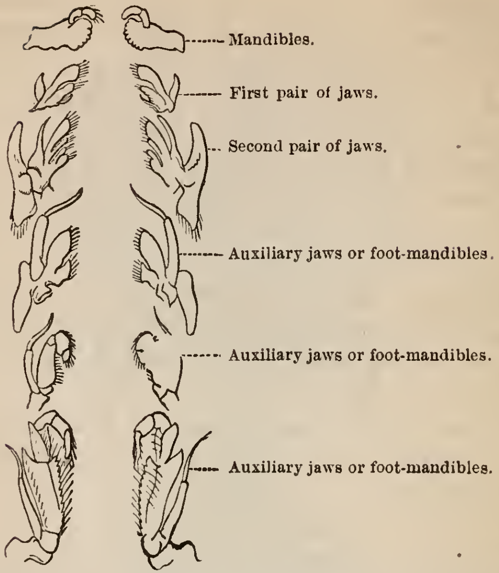
A Crustacean--Craw-fish as seen from below.

although they are modified so as to perform very many and various functions, as those of antennæ, eyes, jaws, claws, feet, paddles, and tail—that is, these apparently very different organs are only modified locomotive appendages!

The mouth is situated underneath and somewhat back from the anterior border of the head. The gullet is short, the stomach large, and the intestines slender.

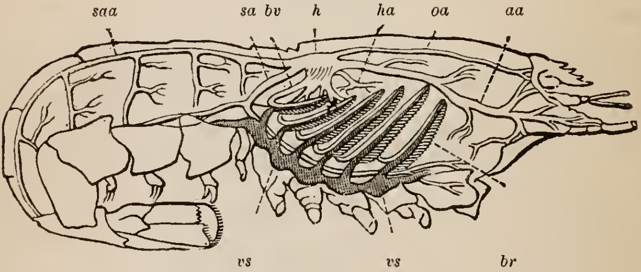
The blood is colorless, or nearly so, and is kept in motion by a heart situated just under the top of the back,

FIG. 478.


Mandibles.
First pair of jaws.
Second pair of jaws.
Auxiliary jaws or foot-mandibles.
Auxiliary jaws or foot-mandibles.
Auxiliary jaws or foot-mandibles.

The six pairs of locomotive appendages of a Crustacean—Craw-fish—which are modified so as to constitute the masticatory apparatus.

FIG. 479.


saa
sa
bv
h
ha
oa
aa
vs
vs
br

Circulatory and Respiratory apparatus of a Crustacean—Craw-fish.

aa, antennar artery; *oa*, ophthalmic artery; *ha*, hepatic artery; *h*, heart; *bv*, branchio-cardiac vessels carrying blood from the branchiæ to the heart; *sa*, sternal artery; *saa*, superior abdominal artery; *vs*, *vs*, venous sinuses receiving blood from the various parts of the body, and transmitting it to the branchiæ or respiratory apparatus *br*.

and composed of a single cavity. The respiratory organs consist of branchiæ or gills (Fig. 479), as already stated.

The voluntary muscles are composed of colorless fibres, inserted on the interior of the solid covering or crust, which may be called an external skeleton.

The nervous system consists of a double series of ganglions, situated on the ventral side of the body, and connected with the cephalic ganglions situated before and above the gullet.

The sense of sight is present in nearly all; that of hearing is indicated by organs only in the highest. Little is known in regard to their sense of smell or taste. Their sense of touch is highly developed.

The Crustaceans have a wonderful power of repairing injuries to themselves. If a leg, or other appendage, be broken off, another like it soon grows in its place!

But one of the most remarkable facts regarding the Crustaceans is that from time to time they shed the shell in one piece, so that the cast-off shell looks exactly like the perfect animal—antennæ, eyes, jaws, legs, paddles, and even every hair, are all just as they were when they covered the living crustacean! The animal comes out of its shell through a rent on the back, and is at first very soft; it at once increases in size, and in a few days its skin becomes as hard as the shell which it cast off. This shedding of the shell is necessary for the growth of these animals; for while the shell remains the Crustacean can grow only just large enough to completely fill it.

When a Lobster is ready to shed its shell, there are two hard stone-like bodies at the sides of the stomach, and it is supposed that these furnish a part of the solid matter for the new shell; for they immediately begin to grow smaller after the moulting, and soon entirely disappear.

The Crustacea have been variously divided, some naturalists recognizing few orders, others many.*

Professor Verrill, the eminent Zoologist of Yale College, has adopted the following classification of the Crustacea. It is a modification of that of G. O. Sars (Fresh-water Crustacea of Norway):

I. SUB-CLASS, MALACOSTRACA.

ORDER I. THORACOSTRACA = PODOPHTHALMIA (nearly).

Sub-order I. DECAPODA (including Brachyura, Anomoura, Macrura, and Schizopoda (*Mysis*).
" " II. STOMAPODA or Squilloidea.
" " III. CUMACEA (*Diastylis*).

ORDER II. ARTHROSTRACA = TETRADECAPODA.

Sub-order I. AMPHIPODA.
" " II. ISOPODA.

II. SUB-CLASS, ENTOMOSTRACA.

ORDER III. LIMULOIDEA.
" IV. TRILOBITA.
" V. PHYLLOPODA.
" VI. CLADOCERA.
" VII. COPEPODA (including *Lernæa, Caligus, Argulus*, etc.).
" VIII. OSTRACODA.
" IX. CIRRIPEDIA.

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* Excluding the Cirripedia, Milne-Edwards recognizes the following Orders of the Crustacea:

1. Decapoda, including Brachyura, Anomoura, Macroura.
2. Stomapoda, as Mysis, Squilla, etc.
3. Amphipoda, as Gammarus, Talitra, etc.
4. Læmodipoda, as Caprella, Cyamus, etc.
5. Isopoda, as Idotea, etc.
6. Phyllopoda, as Branchipus, Limnadia, Nebalia, etc.
7. Cladocera, as Daphnia, etc.

Having now made the student acquainted with several classifications of the Crustacea, we have decided to adopt, for our present purposes, the classification proposed by Professor J. D. Dana, who recognizes only three Orders :—

1. Decapoda or Ten-footed Crustaceans, with only five foot-segments; as Crabs, Lobsters, Craw-fishes, Shrimps, Prawns, etc.
2. Tetradecapoda or Fourteen-footed Crustaceans, with seven foot-segments ; as Sand-fleas, Wood-louse, etc.
3. Entomostraca or Insect-like Crustaceans, with the body defective as to segments and feet ; as the Horse-shoe Crab, Daphnia, Cypris, Cyclops, Barnacles, etc.

Sub-section II.

The Order of Decapoda or Crabs, Lobsters, etc.

As already indicated, the Crabs, Lobsters, Crawfishes, Shrimps, Prawns, etc., have each five foot-segments ; that is, five segments which bear a pair of so-called feet ; hence

---

8. Copepoda, as Cyclops, etc.
9. Ostrapoda, as Cypris, etc.
10. Araneiformes, as Pycnogonon, etc.
11. Syphonostoma, as Caligus, etc.
12. Lernæiformes, as Lernæa, etc.
13. Xyphosura, as Limulus.

Dr. A. S. Packard, jr., writes me that he is inclined to classify the Crustacea essentially thus :

Sub-class I.

Decapoda,
Tetradecapoda,
Nebaliadæ,
Phyllopoda,
Cladocera,
Ostracoda,
Copepoda (including Siphonostoma),
Cirripedia.

Sub-class II.

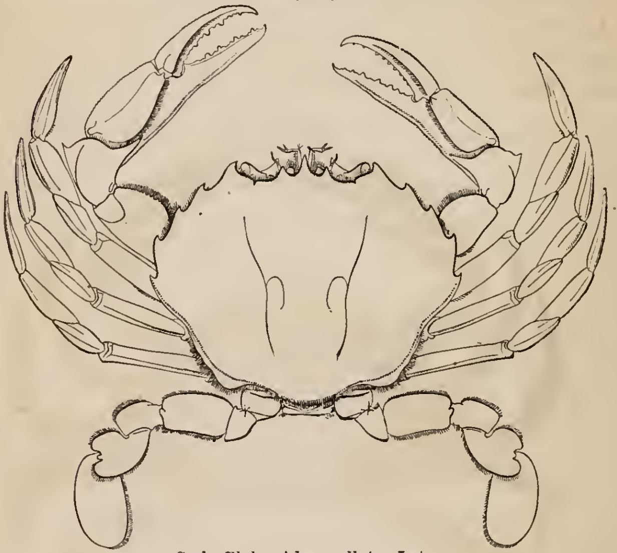
Trilobata,
Merostomata.

the name of this order is called Decapoda, from the Greek *deka*, ten, and *pous*, *podos*, foot.

The Decapoda, as regarded by Dana, are essentially equivalent to the Podophthalmia of authors (from the Gr. *pous, podos*, foot, and *ophthalmos*, eye—the eyes being on movable footstalks), and include not only the typical Decapods—Brachyurans, Anomourans, and Macrourans (Figs. 480–485)—but they also include the Schizopods (from the Gr. *schizein,* to divide, and *pous, podos,* foot—the legs having each an accessory-jointed branch, as in *Mysis,* Fig. 488), and the Stomapods (*Squilla,* Fig. 487).

The typical Decapods, or best representatives of the group, have nine segments belonging to the head, and six pairs of appendages in the oral apparatus (Fig. 479).

Fig. 480.*



Crab, *Platyonichus ocellatus,* Latr.

The Crabs, of which there are many families, are regarded as the highest members of the Decapods, and together they constitute a great group called the BRACHYURA, from the Greek *brachus*, short, and *oura*, a tail. These crustaceans have the hind body or abdomen—popularly called the tail—shorter than the cephalo-thorax, and, in a state of rest, brought forward under the latter, where it fits into a groove. In the males, the abdomen is triangular, and furnished at the base with two or four horn-like appendages; in the females, it is wider, and has beneath it four pairs of double hairy appendages to which the eggs adhere when they are laid.

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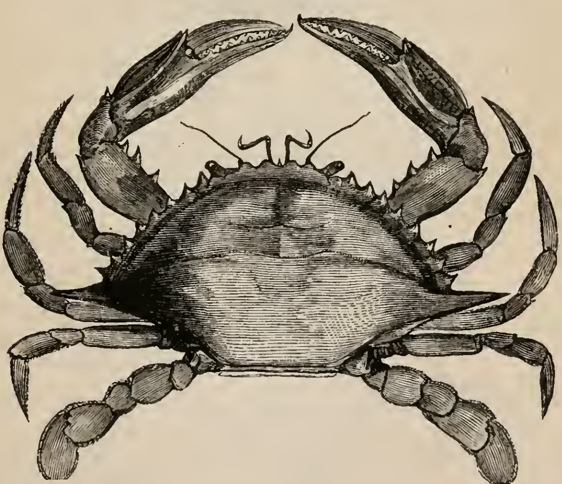
* Figs. 480, 484, 488, 489, 491, 493, and 501, are, by permission, from the "Report upon the Invertebrates of Vineyard Sound and Adjacent Waters," by A. E. Verrill and S. I. Smith.

Crabs vary in size from a fraction of an inch across, to those which, with the legs spread out, cover a space of more than a yard square.

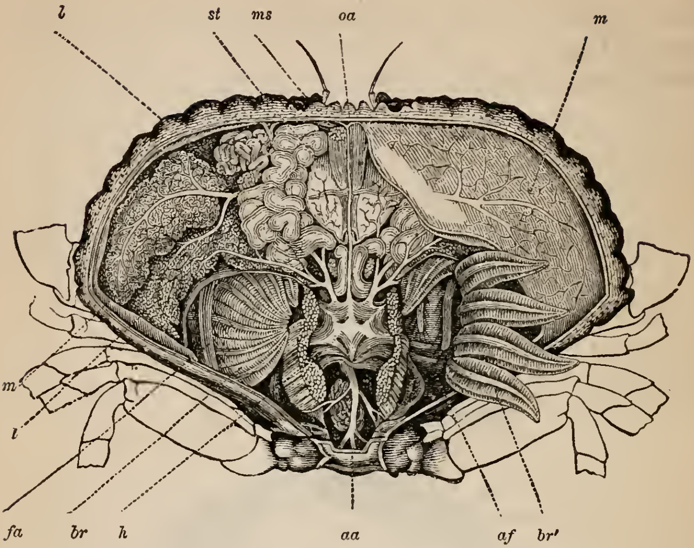
FIG. 481.



American Edible Crab, *Lupa dicantha*, Milne-Edwards. Reduced one half.

Crabs undergo great changes after they leave the egg, before they acquire the form of the parent. In a word,

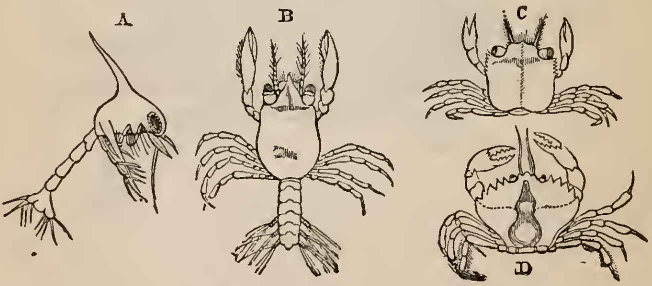
Fig. 482.



Crab, with most of the shell of the Cephalo-thorax removed.

m, membranous lining of the shell; *h*, heart; *oa*, ophthalmic artery; *aa*, abdominal artery; *br*, branchiæ or gills; *br′*, branchiæ turned back; *af*, arch of the flancs; *fa*, flabelliform appendix of the limb-jaws; *st*, stomach; *ms*, muscles of the stomach; *l*, liver.

Fig. 483.

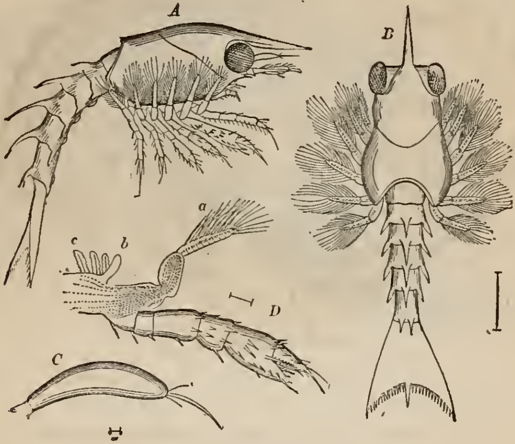


Metamorphosis of the Crab.

A, first or zoëa stage; B, second stage; C, third stage; D, perfect form.

they pass through some of the forms of the lower crustaceans before they assume the form which they are to retain (Fig. 483). The same is true of Lobsters and other decapods (see Fig. 484).

FIG. 484.



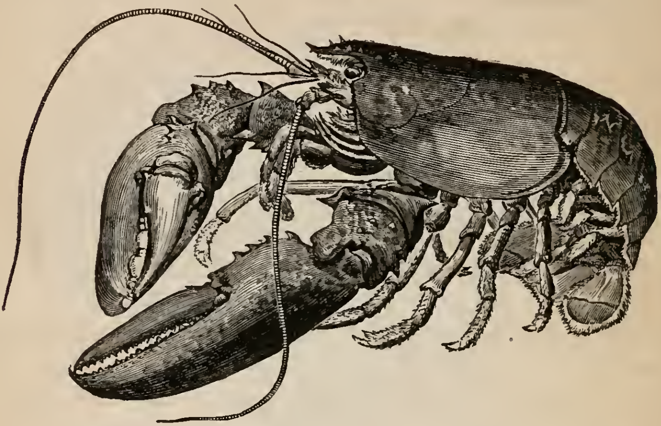
American Lobster, *Homarus americanus*, Edwards—in the larval stage. *A*, lateral view; *B*, dorsal view; *C*, antennula; *D*, thoracic leg.

The movements of Crabs are very curious; as they move forward, backward, sidewise, and obliquely, apparently with equal facility.

The curious decapods known as Hermit Crabs (*Pagarus*, etc.), " back" into the dead shells of gasteropods, and there remain, carrying the shell with them wherever they go, as long as it is large enough to accommodate them. When they outgrow their home, they abandon it and back into another shell. The Hermits and their allies are the ANOMOURA—from the Gr. *anomoios*, unlike, and *oura*, tail; they have the hind body very unlike that of other decapods, being mainly soft and deficient in appendages.

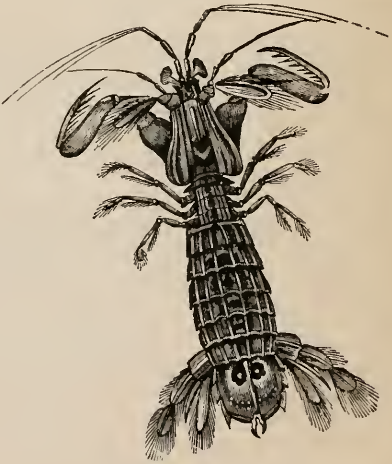
The Lobsters, Crawfishes, Shrimps, etc., have a long abdomen or "tail," and this is curved downwards and

FIG. 485.



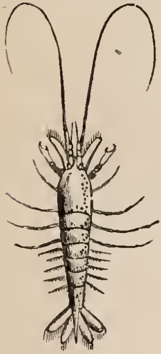
American Lobster, *Homarus americanus*, Edwards.

FIG. 487.



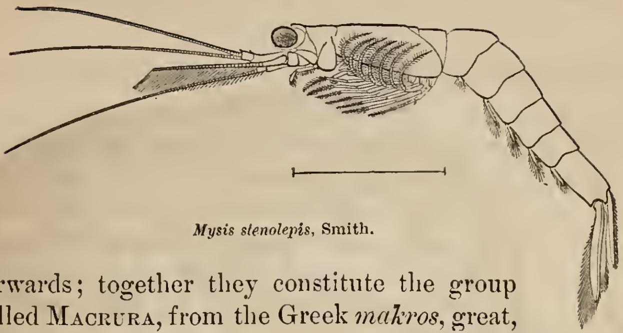
Sea-Mantis, *Squilla mantis*.

FIG. 486.



Bait Shrimp,
Crangon septemspinosus, Say.

Fig. 488.



Mysis stenolepis, Smith.

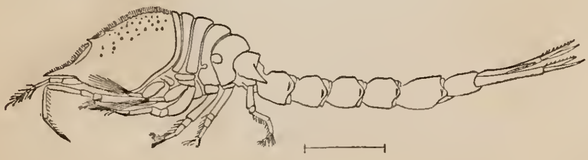
forwards; together they constitute the group called Macrura, from the Greek *makros*, great, and *oura*, a tail.

The Sea-Mantis and its allies are often called Gastrura—from the Gk. *gaster*, stomach, and *oura*, tail—because, unlike the preceding groups, they have the viscera extending into the abdomen. They are also called Stomapods—from the Greek *stoma*, a mouth, and *pous*, *podos*, a foot—because several of the organs which normally belong to the mouth have the form of feet.

Although the Stomapods—Squilloidea (*Squilla*, etc.) are related to the typical decapods; they differ so much from the latter, that Milne-Edwards, and some others, regard them as an order entirely distinct from the Decapods.

Some other decapod-like crustacea (*Diastylis*, etc.), which vary from all those now noticed, are referred to a group named Cumacea.

Fig. 489.



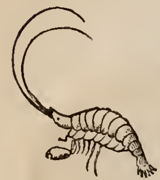
Diastylis quadrispinosa, G. O. Sars.

SUB-SECTION III.

THE ORDER OF TETRADECAPODA OR FOURTEEN-FOOTED CRUSTACEANS.

THE living representatives of this group are mostly of very small size, few attaining even an inch in length. They have seven foot-rings or segments, bearing seven pairs of locomotive appendages, or so-called feet. The scientific name of the order, it will be seen, means fourteen-footed.

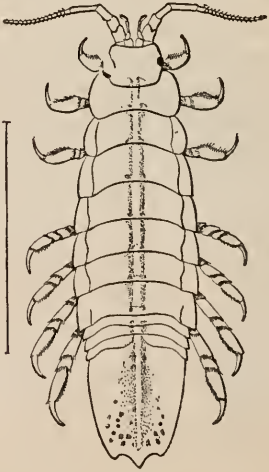
FIG. 490.



A Tetradecapod—Sand-Flea, *Orchestia longicornis*, Gould.

The ISOPODA—from the Greek *isos*, equal, and *pous*, a foot—have the body flattened horizontally, and their locomotive appendages or legs very much alike. Their four posterior pairs of legs are in one series, and

FIG. 491.



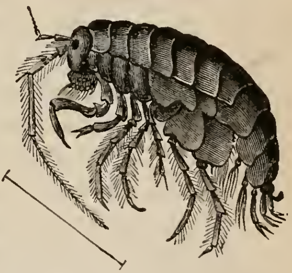
Isopod, *Idotæa irrorata*, Edwards.

the three anterior in another series; and their branchiæ are abdominal.

Many of the marine species are parasitic in their habits. Some kinds live in fresh waters. Those called Wood-lice (*Oniscus*) and the Pill-bugs (*Armadillo*) live on the land in damp cellars, and under rubbish in damp places.

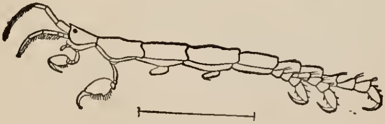
The Amphipoda, as the Sand-fleas (*Orchestia*, *Talitrus*, and *Gammarus*), have the thoracic legs in two series, and the four anterior pairs are directed forwards, and the three posterior pairs backward. And their respiratory organs are in the form of membranous vesicles, attached to the base of the legs. The name is from the Greek *amphi*, both, and *pous*, foot, and may refer to the fact that the Amphipods have both thoracic and abdominal appendages, or to the fact that in the legs are combined both locomotive and respiratory organs; or to the fact that the feet are arranged in two series, one pointing forward, and the other backward.

Fig. 492.



Beach, or Sand-Flea, *Talitrus locusta.*

Fig. 493.



Caprella geometrica, Say.

The Whale-lice (*Cyamus*), *Caprella*, etc., are crustaceans which bear a resemblance to the Amphipods in the arrangement of the respiratory organs, but differ in having a rudimentary abdomen;—authors describe these forms under the name of Læmodipods (from the Greek *laimos*, throat, *di*, two, and *pous*, foot).

Sub-section IV.

The Order of Entomostraca or Entomostracans.

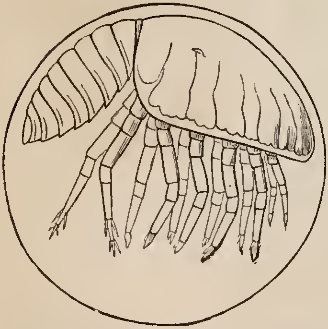
The Entomostraca are crustaceans which are defective both in segments and feet, as compared with the two preceding orders, and rank lower. The name is from the Gr. *entomos*, an insect, and *ostrakon*, a shell.

Normally they have six, or five, cephalic rings, and eight or nine posterior rings belonging to the foot series. More or less of these, however, are usually wanting. The abdomen is also without appendages.

The Merostomata (from the Greek *meros*, thigh, and *stoma*, mouth), are entomostracans which are represented by only one living genus (*Limulus*—the Horse-shoe Crab). The group is often called Limuloidea, and also Xiphosura or sword-tailed.

The Horse-shoe Crab attains the length of one or two feet, and is especially remarkable from the fact that it uses the same organs both in locomotion and in eating—the thighs of the

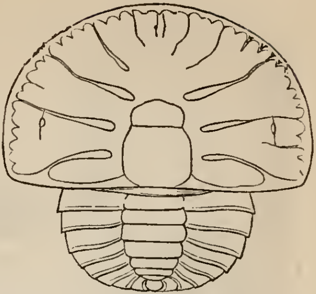
Fig. 494.



Horse-shoe Crab in the egg just before hatching—magnified.

first six legs performing the functions of jaws !

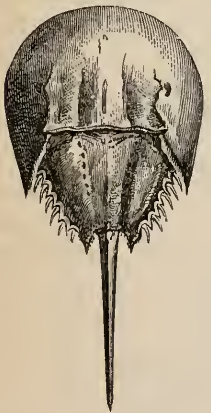
FIG. 495.



Another view of Horse-shoe Crab just before hatching—magnified.

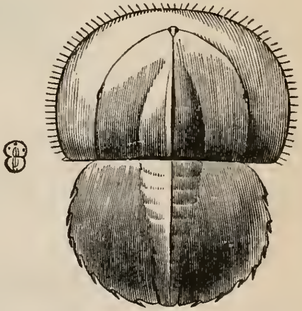
The embryonic stages (Figs. 494, 495, 497) of Limulus—so beautifully represented by Dr. A. S. Packard, Jr.*, — together with the adult forms, suggest the close relationship of the Horse-shoe Crabs with TRILOBATA (Figs. 498, 499), the well-known fossil forms of the Silurian, Devonian, and Carboniferous rocks. And not far removed from the Merostomata and Trilobata are the extinct Eurypterida, which, like the Trilobites, belong to the Palæozoic days of geology.

FIG. 496.



Horse-shoe Crab, *Limulus polyphemus*,—adult. Reduced in size.

FIG. 497.



Horse-shoe Crab soon after hatching—natural size and magnified.

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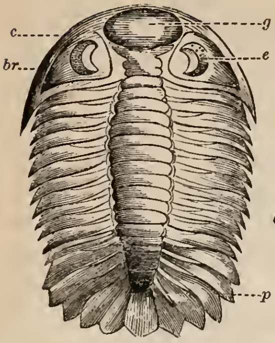
* See Dr. Packard's Paper "On the Development of Limulus Polyphemus," 1872.

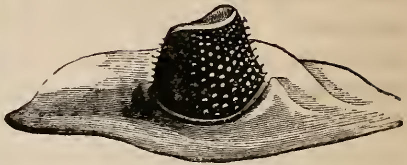
FIG. 498.



Trilobite.

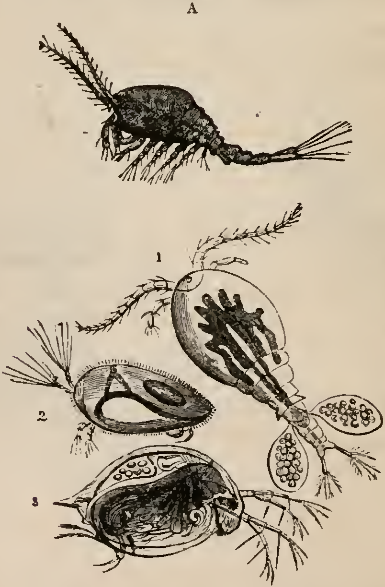
br, buckler; *p*, pygidium; *g*, glabella; *c*, cheeks; *e*, eyes.

FIG. 499.



Eye of a Trilobite, magnified.

FIG. 500.



Minute Entomostracans.—Magnified.

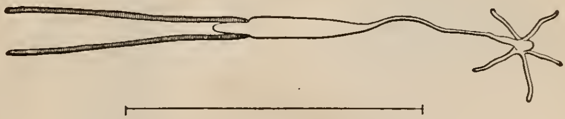
A, *Cyclops*—side view; 1, *Cyclops*, with cluster of eggs on each side of the tail—top view; 2, *Cypris;* 3, *Daphnia.*

The PHYLLOPODA (from *phullon*, a leaf, and *pous*, foot), have long and more or less shrimp-like bodies, with numerous leaf-like appendages which serve both for locomotive organs and gills. They are found in both fresh and salt water. One genus (*Artemia*) is found in salt-vats at salt works; and it abounds in Great Salt Lake, Utah, the water literally swarming with them in some places. *Branchipus* abounds in ponds, and is rather long and slender. *Limnadia* has a bivalve shell, and thus externally resembles Daphnia and Cypris. *Nebalia* reminds some naturalists of the Decapods, while others (see p. 355) are inclined to regard the genus as belonging to a distinct order.

The CLADOCERA (Water-fleas or *Daphnia*, etc.), like the Phyllopods, are without branchiæ, but like the latter have their thoracic members so formed as to serve the purpose of respiratory organs. In most cases their eyes are merged together so as to make them appear as one-eyed; and their cephal thorax is covered by a bivalve shell. The name is from the Gr. *klados*, a branch, and *keras*, a horn.

The COPEPODA—from the Greek *kope*, an oar, and *pous*, a foot—are very small or minute species, of a form reminding us somewhat of shrimps and crabs. *Cyclops* is only about one-sixteenth of an inch in length, and has apparently only one eye (Fig. 500, A and 1). *Caligus* and *Argulus* are parasitic on fishes; the latter upon fresh-wa-

FIG. 501.

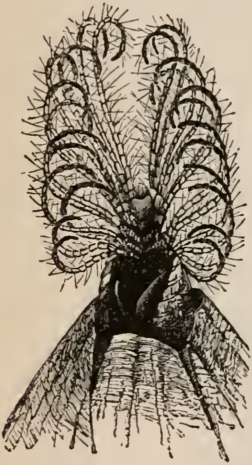


Lerneonema radiata, Steenstrup and Lütken.

ter fishes, and is common on the pickerel, especially on the gills. The two last-named genera belong to the Siphonostoma of authors. And to the Siphonostoma also may be referred the strangely-formed parasites *Lernea* and *Lerneonema* (Fig. 501), etc., formerly described under the name of Epizoa.

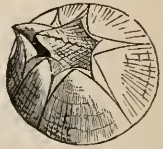
The Ostracoda (*Cypris*, etc.) have no branchiæ, nor any modification of limbs to serve for branchiæ—so far as is apparent; the body does not exhibit distinct segments, and is wholly inclosed in a bivalve shell. The name is from the Greek *ostrakon*, a shell. Cypris is very minute, and abounds in ponds and pools. Fossil shells of extinct

Fig. 502.



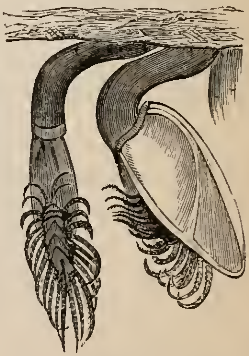
Acorn Barnacle, *Balanus*,—with appendages extended.

Fig. 503.



Acorn Barnacle—appendages drawn in.

Fig. 504.



Stalked Barnacle, *Lepas*.

species of the Phyllopoda, Cladocera, and Ostracoda abound in the rocks of all countries.

The Cirripedia or Barnacles are also covered with a shell in their adult state; and at this time they are attached to rocks, shells, etc. In the young state they are naked, and free to move about. The name is from the Greek *cirrus*, a curl of hair, and from the Latin *pes*, a foot.

The Rotifera, formerly placed as the lowest group of the Crustacea, are now by most authors classed with Vermes, where we briefly notice these minute forms.

SECTION IV.

THE CLASS OF VERMES OR ANNULATA OR WORMS.

SUB-SECTION I.

THE WORMS CONSIDERED AS A CLASS.

NATURALISTS are not fully agreed as to the limits of the Class of Worms.*

It may be stated, however, that Worms are the lowest of all the Articulates—that is, the simplest expression of the Articulate plan. It may be stated, in general terms, that they are much elongated, and similar in form throughout their whole extent. The head segments in many cases, however, are quite different from the others, and more or less highly specialized.

As already implied, there is no division of the body into regions, as we have seen in Insects and in Crustaceans; and none of the Worms have jointed legs, as in those classes. In many cases, however, they have tubercles,

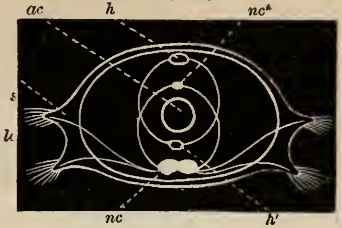
---

* Professor Edward S. Morse (*On the Systematic Position of the Brachiopoda*), after a long series of investigations, has come to the conclusion "that in every point of their structure the Brachiopoda are true worms, with possibly some affinities to the Crustacea, and that they have no relations to the Mollusca, save what many other worms may possess in common with them." Professor Morse is supported in this view by many of the ablest investigators of the present day.

But as the subject is still under discussion, we have decided that it will be better, for our present purposes, to describe the Brachiopoda in their old place under the Mollusca (see p. 432).

Every student, however, should read the Paper cited above, where he will find, clearly presented, the reasons why Professor Morse regards the Brachiopods as true Vermes.

Fig. 505.



Transverse section of a Worm.

s, skin or body wall; *nc*, double nervous cord or nervous ganglions; *ac*, alimentary canal; *h*, heart or dorsal vessel; *lo*, locomotive organs or tubercles tipped with bristles or hairs; *nc'*, supplementary nervous cord; *h'*, supplementary circulatory vessel.

bristles (Fig. 505), or plates which serve as locomotive organs. Those provided with bristles or setæ, are called Chætopods, from the Gr. *chaite*, hair, and *pous*, a foot.

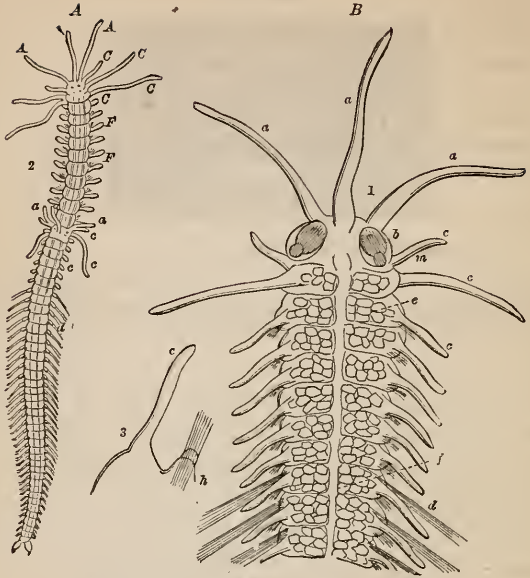
Their digestive system is very simple. Their circulatory system is but little more than a dorsal vessel or so-called heart. Their blood in many cases is red. They respire by means of branchiæ, or by the whole surface of the body. Their nervous system, even when present, is nearly equally distributed among the different segments.

The Annelida have the sense of touch highly developed, and many are provided with tactile organs. As to sight, in many (*Serpula*, *Lumbricus*, etc.) eyes are wholly wanting; in others there are two or more very distinct eyes. Organs of hearing have been detected in some; and it is believed that many can perceive sounds.

Worms multiply by means of eggs; and some kinds also increase by gemmation or fission—that is by self-division (Fig. 506). A few are viviparous. In most kinds the sexes are distinct; but in some kinds (Earthworms, Leeches, etc.) the two sexes are united in the same individual.

Worms live in the water, in mud, in damp earth, and

Fig. 506.



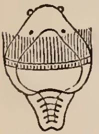
Marine Worm, *Autolytus cornutus*, A. Agassiz.

A, an asexual individual from which a male is about to separate—enlarged six diameters. *A*, antennæ; *C*, tentacles; *F*, intestine; *d*, setæ.

B, part of a female enlarged; *b*, eye; *e*, eggs; *f*, intestine; 3, one of the appendages of the anterior region of the body; *c*, dorsal cirrus; *h*, setigerous tubercle.

in the bodies of other animals. They vary greatly in form, size, structure, and habits—so greatly that naturalists have classified these low articulates in various ways. And it may be added here that in most cases the very young worm is quite different from the parent.

Fig. 507.



Young Worm. Terebella.

For our present purposes we recognize the Class of Worms or Vermes or Annulata as divisible into two Sub-classes:—

I. ANNELIDA, including the more typical forms, together with Gephyrea; as Errantia or Dorsibranchiata (Lob-worms, etc.);

Tubicola (Serpula, etc.); Terricola (Earth-worms); and Suctoria (Leeches).

II. HELMINTHA OR ENTOZOA OR SCOLECIDA, including, together with Turbellaria, worms which have their abode during a portion, or all of their lives, in the bodies of other animals; as Trematoda (Flukes); Cestoidea (Tape-worms); Acanthocephala (Spine-headed worms); Nematoidea (Thread-worms), etc.

These Sub-classes,* and the divisions of them, which may be provisionally treated as Orders, are here presented in one view, together with the names of the groups of which these are regarded as the equivalents :—

---

* Huxley (*Introduction to the Classification of Animals*) classifies the Verminiform articulates essentially in this way:—

- Annelida.
  - Chætophora.
    - Errantia.
    - Tubicola.
    - Terricola.
    - Gephyrea.
  - Discophora.
    - Suctoria.
- Scolecida.
  - Trematoda.
  - Tæniada.
  - Turbellaria.
  - Acanthocephala.
  - Nematoidea.
  - Rotifera.

Rollestone (Forms of Animal Life) regards the Vermes as a Sub-kingdom, and divides the group essentially thus:—

- Annulata.
  - Class 1. Annulata proper.
    - Sub-class Chætophora.
      - Polychæta.
      - Oligochæta.
    - Sub-class Discophora.
  - Class 2. Gephyrea.
- Annuloida.
  - Class 3. Nematelminthes.
    - Order Chætognatha (Sagitta).
    - " Nematoidea.
    - " Acanthocephala.
  - Class 4. Rotifera.
  - Class 5. Platyelminthes.
    - Order Turbellaria.
    - " Trematodes.
    - " Cestodes.

ANNELIDA.

1. DORSIBRANCHIATA or Errantia or free Sea-worms with short branchial appendages along the back or body ; as the Lob-worms, etc.	CHÆTOPODA or CHÆTOPHORA.
2. TUBICOLA or Sea-worms which live in tubes ; as the Serpulas, etc.	
3. TERRICOLA or Oligochætæ or worms destitute of branchial appendages ; as Earth-worms.	
4. GEPHYREA or Smooth-bodied cylindrical worms, formerly classed with the Radiates ; as Sipunculoids and Synaptids.	SIPUNCULOIDA.
5. SUCTORIA or Bdellodea or Leeches ; with sucking disks at the extremities.	DISCOPHORA.
6. CHÆTOGNATHA or free-swimming oceanic worms ; as Sagitta.	
7. GYMNOCOPA, also free-swimming oceanic worms ; as Tomopteris.	

HELMINTHIA.

8. TREMATODA or Flukes ; with a single opening leading to a branching digestive system.	ANNULOIDA.
9. CESTOIDEA or Tape-worms, etc. ; with a tape-like form ; anterior end provided with suckers, or hooks, or foliaceous appendages, or with all these ; and with no alimentary canal.	
10. TURBELLARIA or Turbellarians ; with bodies covered with cilia, and unprovided with suckers. Not parasites. Planaria and Nemertes are examples.	
11. ACANTHOCEPHALA or Spine-headed worms ; with no division into rings or segments ; no alimentary canal ; and with proboscis armed with spines, as Echinorhynchus.	

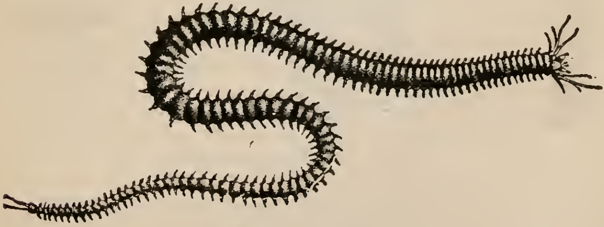
12. NEMATOIDEA or Thread-worms; with a thread-like form; no segments; dense covering; straight alimentary canal; as Hair-worms, etc.	ANNULOIDA.
13. ROTIFERA, minute forms with wheel-like appendages around the head. Referred to the Crustacea by some naturalists.	

SUB-SECTION II.

THE ORDER OF DORSIBRANCHIATA OR LOB-WORMS, ETC.

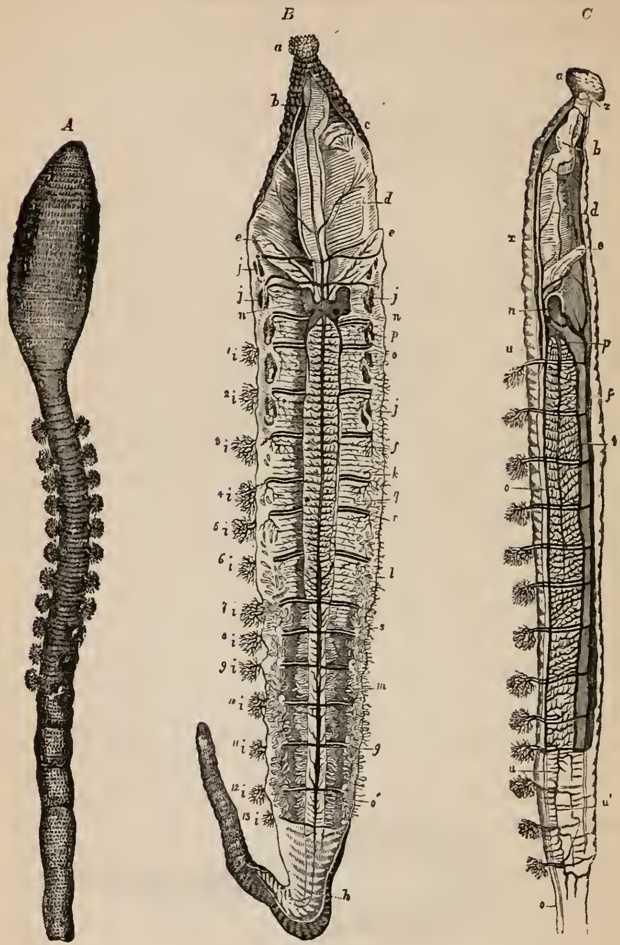
THE worms of this group belong to the sea. Some species swim freely about, and others live in the sand or mud. They get their name from the fact that, in general they have the gills in the form of short branchial appendages along the back or body (Figs. 508–9), from the Latin *dorsum*, the back, and *bragchia*, gills. They are known under the names of Sea-Centipedes or Nereidæ (Fig. 508); Eunicidæ—a West Indian species of which (*Eunice gigantea*) attains the length of four feet; "Sea Mice" or Aphroditidæ, which are more or less covered with silky hairs of a brilliant metallic luster; and the Lob-worms or Arenicolidæ, etc. Here also may be mentioned a remarkable genus called *Cirratulus* a new species of which

FIG. 508.



Sea-Centipede, *Nereis*.

FIG. 509.


A
B
C
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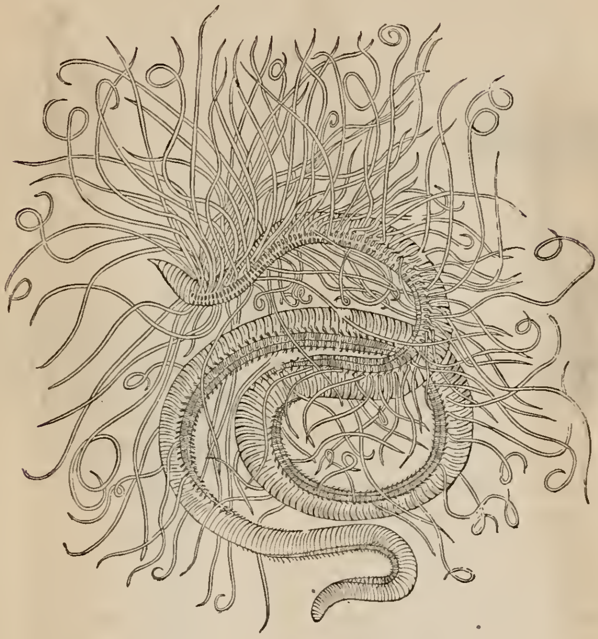
Lob-worm, *Arenicola piscatorum.*

A, external form; B, internal structure as seen from above; C, as seen on the side. *a*, proboscis; *b*, pharynx; *e*, retractor muscles; *d*, crop; *e*, cæcal appendages; *f*, stomach; *g*, intestine; *h*, muscular partition; $'i$-^{13}i, branchiæ; *o*, dorsal vessel.

(Fig. 510) has recently been described and figured by Professor Verrill.*

FIG. 510.



Marine Worm, *Cirratulus grandis*, Verrill.

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* *Cirratulus* is grouped with the Dorsibranchiata of Siebold. But Professor Verrill writes me that he does not recognize Dorsibranchiata as a natural group, but merely an artificial one.

"The long, slender organs *on the sides* of the body of *Cirratulus* are the dorsal cirri, and are not homologous with the branchiæ of *Arenicola*, etc., though they may, and doubtless do act to some extent as branchiæ. But they are more particularly devoted to sensation and locomotion. Some of the *most anterior ones*, however, are different in structure from the rest, though similar in form, and are regarded as true branchiæ."—Verrill.

Professor Verrill writes me that he recognizes two Classes of Worms :—

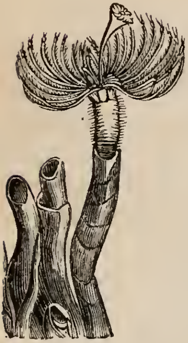
I. ANNELIDA, including six orders, viz. : 1. Chætopoda, 2. Oligochæta, 3. Gephyrea, 4. Bdellodea, 5. Gymnocopa, 6. Chætognatha; and II. SCOLECIDA, including six orders, viz.: 1. Nematoidea, 2. Turbellaria, 3. Trematoda, 4. Acanthocephala, 5. Cestoda, 6. Rotifera.

SUB-SECTION III.

THE ORDER OF TUBICOLA OR SERPULAS, ETC.

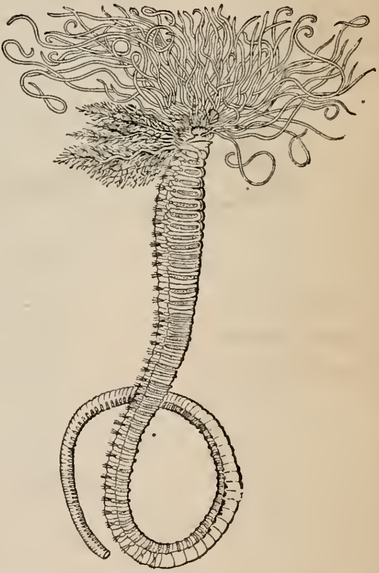
The worms of this group are also confined to the sea, and live in calcareous or membranous tubes which they exude or secrete from their own bodies. Their branchial appendages are situated around the head, in a flower-like cluster, surpassingly beautiful both in structure and color. Their tubes are common on shells, stones, and other bodies in the sea, and are generally more or less bent, curved or contorted; and always closed at the small end and open at the other. These tubes are frequently found penetrating corals and other marine bodies. The Serpulidæ are prominent representatives of this order.

FIG. 511.



Marine Worm. *Serpula.*

FIG. 512.



Amphitrite ornata, Verrill.

The Terebellidæ form their tubes by a glutinous secretion and by pieces of shell and grains of sand which are held together by this secretion. *Terebella*, *Amphitrite*, etc., belong here.

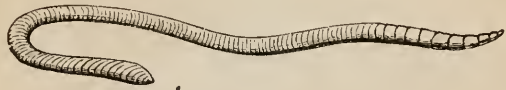
SUB-SECTION IV.

THE ORDER OF TERRICOLA OR EARTH-WORMS.

THE Earth-worms or Lumbricidæ are so well known that we must give them only a passing notice, although they are very interesting in their structure, and exceedingly interesting in their habits.

The Earth-worms have no visible external organs of respiration, but apparently respire by the whole surface of their body. They eat dirt and thus secure the organic matter which it contains.

FIG. 513.



Earth-worm—*Lumbricus terrestris, Linnæus.*

And, contrary to the popular notions, these animals, by their burrowing and working over of the soil confer great benefits upon the farmer and gardener.

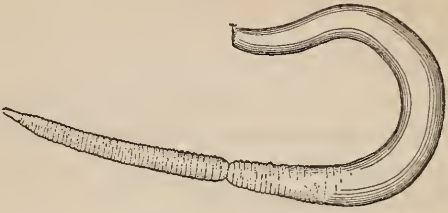
SUB-SECTION V.

THE ORDER OF GEPHYREA.

THE name of this group is from the Gr. *gephyra*, a bridge, and is given to certain marine worm-like forms which are regarded as a sort of connecting link or bridge between the Holothurians (Fig. 670.) and the Vermes.

The Gephyrea are cylindrical in outline, and covered mainly by a soft integument; though chitinous matter is secreted in some cases. The Sipunculoids and Synaptidæ, formerly classed with the Holothurioids, are representatives of this group.

FIG. 514.



Gephyrean, *Phascolosoma Gouldii.*

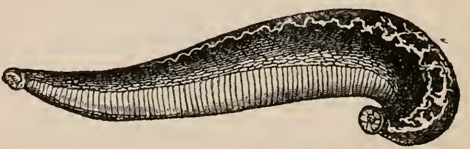
SUB-SECTION VI.

THE ORDER OF DISCOPHORA OR SUCTORIA OR LEECHES.

THE Leeches are provided with à sucking disk at each extremity. The name Discophora is from the Gr. *diskos*, a disk, and *phero*, to bear.

They perform locomotion either by means of these disks, or by swimming. They are found in both fresh and salt water, and are popularly known as Blood-suckers. A species found in Ceylon is wholly terrestrial!

Fig. 515.



Leech, *Sanguisuga officinalis.*

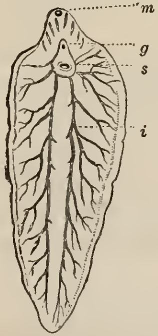
The mouth of the Leech is situated in the anterior sucker or disk, and has around it three jaws in the position of radii, and each of the jaws is armed with two rows of minute teeth, and the jaws are so worked by muscles that a sort of sawing movement is given to each jaw separately.

SUB-SECTION VII.

THE ORDER OF TREMATODA OR FLUKES.

THE worms of this group are more or less elliptical or oval, and flattened; and are parasitic in their habits, being found in the liver of sheep, and of man, and of other animals. The name is from the Greek *trema*, a hole; the Trematods have a branching digestive system, to which there is only one opening—the mouth. They generally have one or more sucking disks, by means of which they adhere to other animals.

FIG. 516.



Lever Fluke, *Fasciola hepatica*, Linn.

m, mouth; *s*, sucker; *g*, genital orifices; *i*, intestinal tubes.

SUB-SECTION VIII.

THE ORDER OF CESTOIDEA, OR TAPE-WORMS.

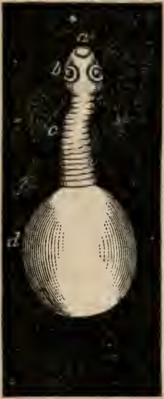
THE name Cestoidea comes from the Greek *kestos*, a girdle. The Cestoids are flat, tape-like worms, and narrow towards the head, but widening behind; in their mature state they live only in the intestines of vertebrate animals. They vary from a few inches to many feet in length. The largest attain, in some cases, the length of one hundred feet. The width is nearly an inch in some of the widest.

The eggs of a cestoid never hatch in the same intestine in which the cestoid lives, but only after they have been taken into the stomach of another and suitable animal. Thence the embryos pierce their way into the blood-vessels, and are carried by the circulation of the blood into various parts of the body, where they develop into larvæ called *hydatids*.

The so-called "measly pork" is pork containing these hydatids; that is, measly hogs are such as have their flesh more or less filled with the larvæ of cestoids or tape-worms. And if the flesh of such hogs be eaten before cooking, which kills the hydatids, the man or animal eating it takes these hydatids into his intestines, where they develop into tape-worms.

And so in regard to all animals which have tape-worms; they get them by eating other animals in whose tissues there exist hydatids. And the way in which those animals afflicted with the hydatids get the latter, is by swallowing some of the infinitesimal eggs of the tape-worm.

FIG. 517.

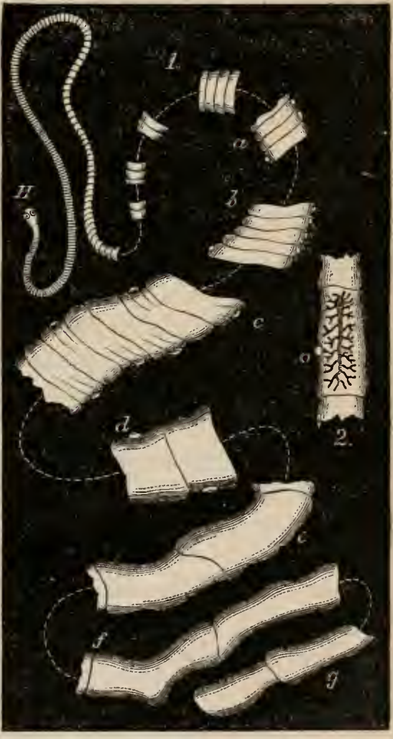


A Larval Tape-worm or Hydatid (*Cysticercus*)—five times the natural size.

a, circle of hooklets; *b*, sucking disks; *c*, neck; *d*, water-bladder. (From Weinland's "Human Cestoides.")

The mature Tape-worm consists of head, neck, and joints. The young tape-worm or Hydatid or Scolex or Cysticercus (from the Gr. *kustis*, a bladder, and *kerkos*, a tail) or "bladder-tail," has only a head, a neck, and a "water-bladder." The neck is constantly growing from the head, and the transverse wrinkles of the neck become the joints or "proglottides" of the body.

FIG. 518.



1. Human Tape-worm, *Tænia solium*, Linnæus—natural size. Only characteristic parts represented.

H, head; *a*, 309th joint; *b*, 448th joint; *c*, 569th joint; *d*, 680th joint; *e*, 768th joint; *f*, 849th joint; *g*, 855th joint.

2. Mature joint of the same, showing the ovary, and ovarian opening (*o*).

This worm measured 10 3-4 feet. (From Weinland's "Human Cestoides.")

The sexes are combined in each proglottis or joint. From time to time the hindmost joints become detached, and in this way the length of the tape-worm is limited, notwithstanding the constant growth of joints from the head and neck.

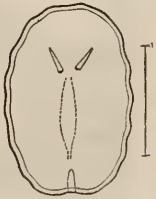
Tape-worms have no mouth nor alimentary canal. Their nourishment is absorbed through the walls of the body.

SUB-SECTION IX.

THE ORDER OF TURBELLARIA.

THE Turbellarians differ from all the other groups placed under the Sub-class of Helmintha in the fact that they are not parasites.

FIG. 519.*



Planarian Worm, *Planocera nebulosa*, Girard.

Most of the Turbellarians inhabit fresh water; some kinds are found in the sea; and a few on the land. They are elongated and flat worms, and are covered with cilia, and are destitute of suckers. *Planaria* and *Nemertes* are examples.

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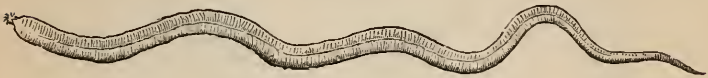
* Figs. 510, 512, 514, 516, 519, 520, 654, and 655, are from the works of Professor A. E. Verrill.

SUB-SECTION X.

THE ORDER OF ACANTHOCEPHALA OR SPINE-HEADED WORMS.

THE worms included in this group are internal parasites which are without perceptible segments, and with no alimentary canal, and which adhere to the intestines in which they live by means of a proboscis armed with spines. One species (*Echinorhyncus gigas*), found in the hog, is eighteen inches long.

FIG. 520.



Spine-headed Worm, *Echinorhyncus gigas*, Gëze.

SUB-SECTION XI.

THE ORDER OF NEMATOIDEA OR THREAD-LIKE WORMS.

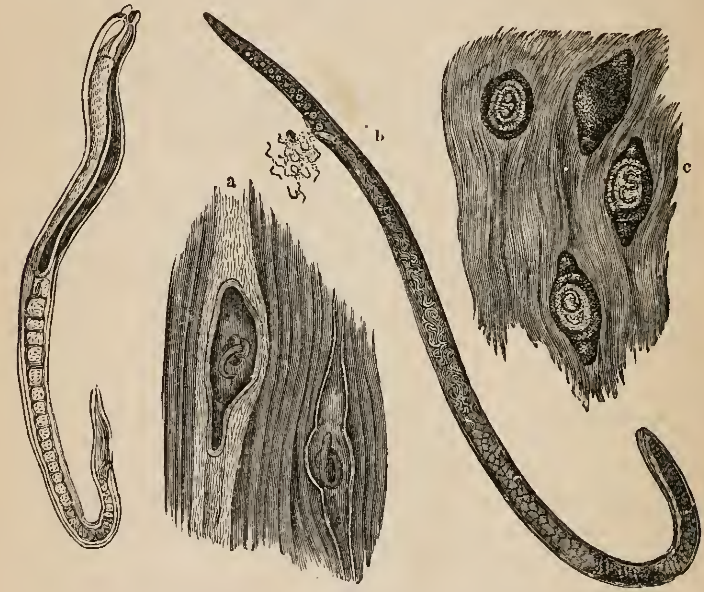
THE name Nematoidea comes from *nema*, a thread, and *eidos*, appearance, and is given to the worms of this order because, in general, they are long, slender, and more or less thread-like.

Their covering or integument is dense, and does not exhibit segments.

This group is about the same as that named Cœlelmintha by authors.

The Nematoids are parasitic in various animals. Some kinds, as the Round-worms (*Ascaris*) and Thread-worms (*Oxyuris*) inhabit the human intestines; *Strongylus* lives in the kidneys of the pig. *Filaria* burrows in the flesh of man in warm climates, and attains the length of six feet. *Trichina*, about one thirtieth of an inch in length, inhabits the flesh of man and of the hog and other animals. The Hair-worm (*Gordius*), lives in the bodies of insects while in the larva state, and in water in the adult state.

FIG. 521.



Free, and encysted Trichinæ, *Trichina spiralis*, Owen.

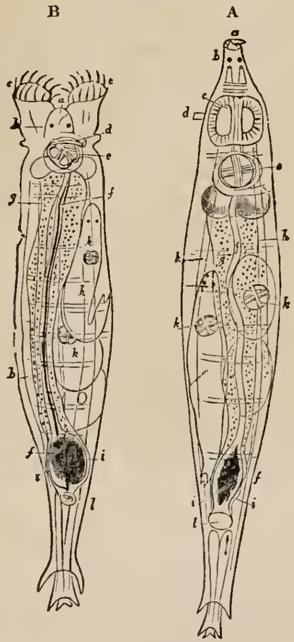
a, *c*, Trichinæ encysted in muscle: *b*, female and young.

SUB-SECTION XII.

THE ORDER OF ROTIFERA OR "WHEEL-ANIMALCULES."

THE Rotifers, as already indicated on page 369, are forms which by some authors are classified with Crustaceans, and by others with Vermes.

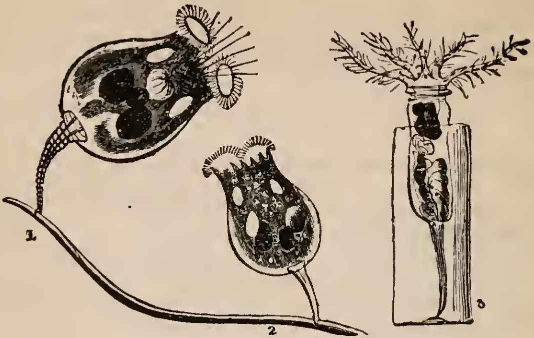
FIG. 522.



Rotifer, *Rotifer vulgaris.*

A, with the "wheels" drawn in; B, with the wheels expanded; *a*. mouth; *b*, eye-spots; *c*, wheels; *d*, antenna? *e*, jaws and teeth; *f*, alimentary canal; *g*, glandular? mass inclosing it; *h*, muscles; *i*, *i*, tubes of the water vascular system; *k*, young animal; *l*, cloaca.

FIG. 523.



Rotifers—Magnified.

1 and 2, *Brachionus*, 3, *Stephanoceros*.

They are aquatic animals, minute in size, mainly microscopic, varying from only one sixteenth of a line to a line in length. They are radiate in general appearance, although not radiate in their interior structure. Their organs of locomotion are delicate appendages or cilia arranged around the summit or head.

PRINCIPAL TOPICS CONSIDERED IN CHAPTER III., SECTION I.

The Articulata as a Branch.——Their external appearance, hard parts, limbs, bilateral symmetry, etc.——Alimentary canal.——Dorsal vessel or heart.——Nervous system.——Classification of the Articulata.

SECTION II.

SUB-SECTION I.

The Insecta as a Class.——Importance of Entomology.——Insecta defined.——Number of species.——Size.——Classification of the Insecta.

SUB-SECTION II.

The Insects proper.——Parts of the body, legs, and wings.——Real nature of the wings.——Ovipositor.——Digestive system.——Circulatory system.——Respiratory system.——Nervous system.——Sight.——Hearing.——Transformations of Insects.——Larva, Pupa, and Imago.——Cocoon.——Partial transformation.

1. The Hymenoptera, their wings, jaws, etc.——2. The Lepidoptera, their wings, mouth-parts, tongue, larvæ, etc.——Butterflies.——Moths.——3. The Diptera, their wings, mouth-parts, larvæ, etc.——4. The Coleoptera, their wings, jaws, etc.——5. The Hemiptera, their wings, mouth-parts, etc.——6. The Orthoptera, their wings, transformations, etc.——7. The Neuroptera, their wings, jaws, larva and pupa state, etc.

SUB-SECTION III.

The Arachnida—general structure.——Eyes.——Legs.——Changes in coming to maturity.——Classification.——1. Araneina or Spiders proper—their form, structure, habits, principal kinds.——2. Pedipalpi or Scorpions.——False-scorpions.——3. Acarina or Mites, Ticks, etc.

SUB-SECTION IV.

Myriapoda—their form, general structure.——1. Chilopoda.——"Earwigs," Centipedes, etc.——2. Chilogn .tha.——"Thousand-legs," etc.

SECTION III.

SUB-SECTION I.

The Crustacea as a Class.——Shell, Segments, Appendages, etc.——Classification of the Crustacea.

SUB-SECTION II.

The Decapoda as an order.——Brachyura.——Anomoura.——Macroura.——Stomapoda, etc.

SUB-SECTION III.

The Tetradecapoda as an order.——Isopoda.——Amphipoda.——Læmodipoda.

SUB-SECTION IV.

The Entomostraca as an order.——Merostomata.——Trilobata.——Phyllopoda.——Cladocera.——Copepoda.——Ostracoda.——Cirripedia.

SECTION IV.

SUB-SECTION I.

The Worms as a Class.——Their form and general structure.——Classification of Worms.

Sub-sections ii., iii., iv., v., vi., vii., viii., ix , x., xi., and xii., treat, respectively, of the Dorsibranchiata, the Tubicola, Terricola, Gephyrea, Suctoria, Trematoda, Cestoidea, Turbellaria, Acanthocephala, Nematoidea, and Rotifera.

CHAPTER IV.

THE MOLLUSCA OR MOLLUSKS.

SECTION I.

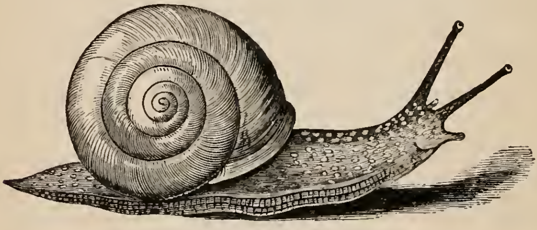
THE MOLLUSCA CONSIDERED AS A BRANCH.

The Mollusca have a soft body which is enveloped by a muscular skin called a mantle, and in most cases protected by a shell; and they are not jointed nor radiated in their internal structure.

The name Mollusca is derived from the Latin *mollis*, soft.

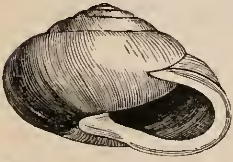
The shells are the parts of these animals which we oftenest see; for when the animal is dead the soft parts soon disappear, and only the shell remains. Curious and wonderful as the shells are, they often give only the faintest idea of the appearance of the animals when alive.

Fig. 524.



A living Mollusk—expanded.

Fig. 525.



Mollusk dead—or contracted.

The shell is a part of the animal, and not a mere house which it enters and leaves at pleasure; although the so-called animal readily expands much beyond the limits of this shell, and withdraws itself wholly within the same again, at will.

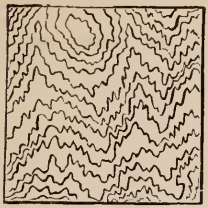
The kinds of Mollusks are very numerous, not less than fifteen thousand. They abound in the sea, on the marshes, in pools, streams, ponds, and lakes, and on the land; and they are full of interest when we study them, and all serve important purposes. They are the food of many other animals. The Right Whale feeds upon small kinds which swim freely in the open sea; the Cod and Haddock and many other useful fishes fatten upon those gathered near or on the bottom; and Sea-birds feast upon those left bare by the tide. Man reckons the Oyster, Clam, and Scallop among his choicest dishes; and in seasons of scarcity the poor inhabitants on many a sea-coast depend upon Mollusks for a large part of their daily food. These animals also furnish the bait for all the extensive fisheries of the North Atlantic. Some kinds yield rich dyes. The celebrated Tyrian purple of the ancients was obtained from shell-fish, as already stated.

The shells of Mollusks are limestone or carbonate of lime. Pearly within, and even without when polished, and of soft and delicate colors, they are often exceedingly beautiful, and are eagerly sought for. The child gathers them for toys, and thinks he hears the roaring of the sea as he puts them to his ear. The savage wears them as ornaments, and some of them as marks of chieftainship. Some kinds are gathered by civilized nations and used instead of money in trading with barbarous tribes. Other kinds are gathered and wrought into almost numberless articles of use and luxury. And the true naturalist, more enthusiastic than all others, traverses sea and land, and cheerfully endures hunger, thirst, and fatigue that his collection of shells may lack neither "Argonaut" nor "Nautilus," "Cone," "Cowry," nor "Wentle-trap," "Helix" nor "Limnæid," "Pecten," "Mother-of-Pearl," nor "Unio," nor any other which will enable him to understand more clearly this department of the animal kingdom, and the works of God as revealed in these wonderful objects.

In general, the shells of Mollusks are composed of carbonate of lime, and the texture varies with the kinds, as shown when exceedingly thin sections are examined with the microscope (Figs. 526–8).

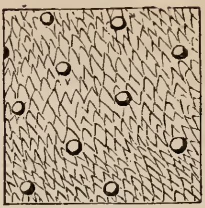
The Mollusca are well provided with organs by which food is secured and digested. Their blood is colorless, or

Fig. 526.



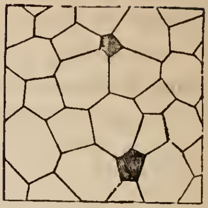
Magnified portion of Pearl-shell.

Fig. 527.



Magnified portion of Pinna.

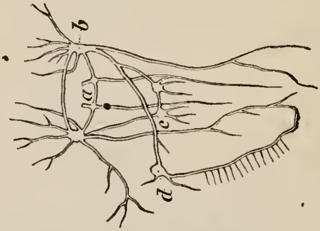
Fig. 528.



Magnified portion of Terebratula.

not red. Their circulatory system consists of a heart, arteries and veins, and venous sinuses. Their respiratory organs are gills, or lung-like cavities. Their muscular system is well developed. Their nervous system is mainly in the form of a ring which surrounds the œsophagus or throat, from which nervous filaments radiate and connect with other nervous ganglia in other parts of the body.

Fig. 529.



Nervous System in the Mollusca.

a, *b*, *c*, *d*, nerve-ganglions.

The principal center of the nervous system is in the form of a ring surrounding the gullet.

As to reproduction, most kinds of mollusks increase by means of eggs. Some kinds, as the River-Snails (*Paludina*), etc., are called viviparous, because they retain the eggs in the oviduct till after they are hatched, and the young have attained a considerable size. Some kinds of tunicate mollusks increase by budding.

In the highest mollusks, the sexes are distinct; but united in Land-Snails, and in some kinds of bivalves, etc.

According to the most generally received classification, the Mollusca include six Classes:

I. CEPHALOPODA or cephalopods; with distinctly marked head, which is furnished with fleshy appendages or arms; two prominent eyes; two stout horny jaws; and the body naked, or protected by a shell.	MOLLUSCA VERA.
II. GASTEROPODA or Gasteropods; with a more or less well defined head; and with the lower portion of their body formed for a locomotive organ; and in most cases with a univalve shell.	
III. ACEPHALA or Conchifera or Bivalves; with apparently no head, and with a shell composed of two pieces or valves.	
IV. TUNICATA or Ascidians; with a soft elastic covering instead of a shell.	MOLLUSCOIDEA.
V. BRACHIOPODA or Arm-footed animals; with two ciliated arms; a shell of two valves, a dorsal and a ventral, and the two valves of unequal size, but equal sided.*	
VI. POLYZOA or Bryozoa or moss-like Mollusks, growing in clusters.	

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* See foot, note in regard to Brachiopods, on p. 370.

SECTION II.

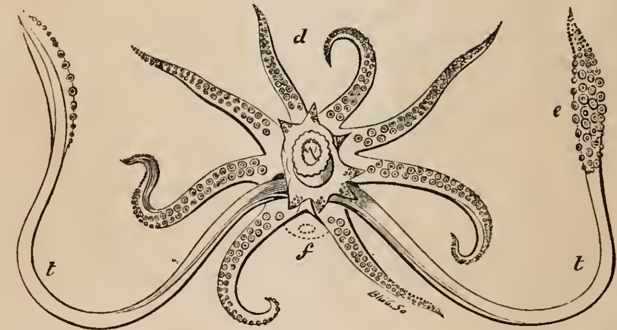
THE CLASS OF CEPHALOPODA OR CEPHALOPODS.

SUB-SECTION I.

THE CEPHALOPODS CONSIDERED AS A CLASS.

THE Argonauts or Paper-sailors, Cuttle-fishes, Squids, and other Cephalopods, have a mouth armed with a stout beak, resembling that of a parrot, a large eye on each side of the head, and, surrounding the mouth, long, muscular arms, or tentacles, covered with cup-like suckers, by means of which they cling with the greatest firmness to whatever they lay hold of.

FIG. 530.

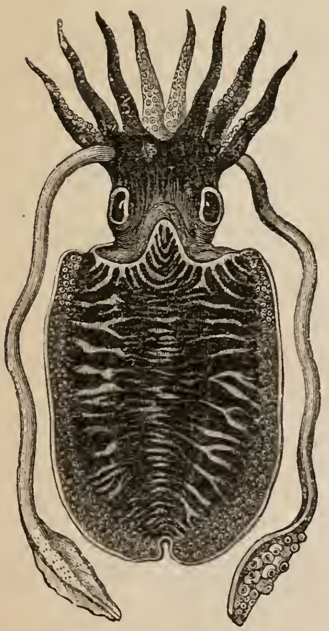


Oral view of the Mandibles and "arms" of a Cephalopod *t*, pedunculated tentacles with their enlarged extremities *c* ; *d*, dorsal arms ; *f*, funnel.

The Cephalopods are marine, and many kinds have within the body a sac containing an ink-like fluid with which they cloud the water, and thus conceal themselves whenever they wish to escape from an enemy.

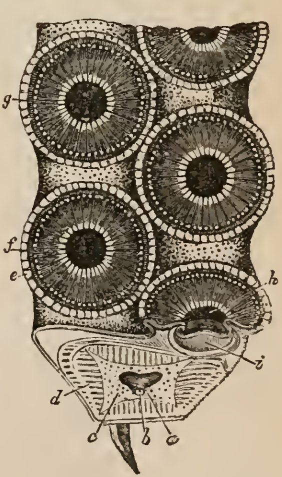
The word Cephalopod comes from the Greek *kephale*, head, and *pous* a foot, and is given to these Mollusks because their locomotive organs are attached to the head, as just described. These animals have a most wonderful power of changing their colors—the hues of some kinds varying almost every moment. They swim by ejecting water from their "funnel," and by means of their arms, and they crawl on the bottom with the head downwards. They are very voracious, eagerly devouring fishes and other

Fig. 531.



Cuttle-fish. *Sepia officinalis*, L. Much reduced. Britain.

Fig. 532.



Suckers of the Cuttle-fish.

animals readily, tearing their flesh in pieces with their stout hooked beaks.

Some kinds of Cephalopods attain an enormous size. Aristotle gives an account of one which was five fathoms in length! In 1853 a cuttle-fish whose tentacles were five or six inches in diameter was cast upon the shores of Jutland. In 1861 the officers and crew of the French steamer *Alecton* saw one, northeast of Teneriffe, which was estimated to be fifteen feet in length, with arms five or six feet long!

But the most gigantic species of Cephalopods ever seen have been obtained during the past few years in the North Atlantic, near Newfoundland, * some of which have the body from 10 to 19 feet long, and about 2 feet in diameter, and the "arms" more than 30 feet in length—the total length of the Cephalopod, in some cases being 40 or 50 feet! These gigantic mollusks have the general form of the Squids (*Loligo*, Figs. 536 and 537).

There are two Orders of the Cephalopoda:—

1. DIBRANCHIATA or Two-gilled Cephalopods; as *Argonauta*, *Loligo*, etc.
2. TETRABRANCHIATA or Four-gilled Cephalopods; as *Nautilus*, *Ammonites*, etc.

SUB-SECTION II.

THE ORDER OF DIBRANCHIATA OR TWO-GILLED CEPHALOPODS.

THIS Order comprises cephalopods which have two branchiæ, an ink-gland, and, with few exceptions, a rudimentary internal shell—the so-called "cuttle-bone." Representatives are found in all latitudes, and in open ocean as well as near the shores. The Dibranchiata include the Argonaut, Octopus, Cuttle-fishes, Spirula, Squids, etc.

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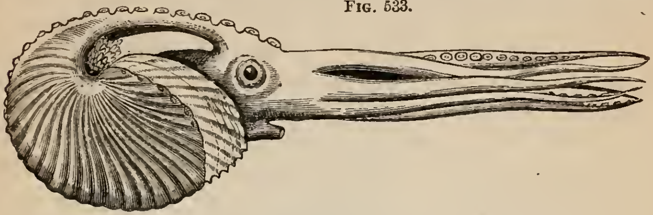
* See American Naturalist on "*The Colossal Cephalopods of the North Atlantic*," by Professor A. E. Verrill.

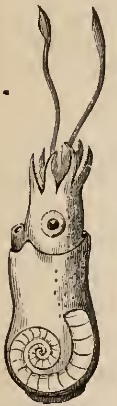
The skin of the naked cephalopods contains variously

FIG. 533.



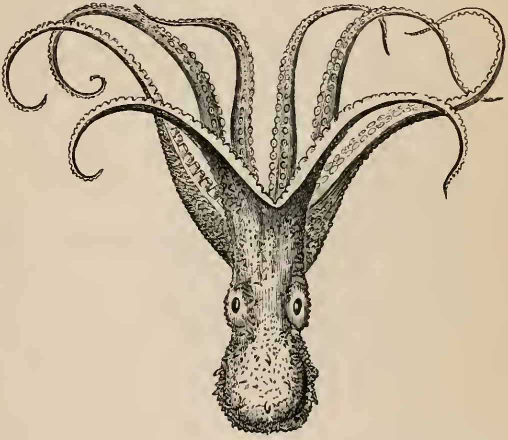
Argonaut or Paper-Sailor, *Argonauta argo*, Linn. Much reduced. Warm Seas.

FIG. 534.



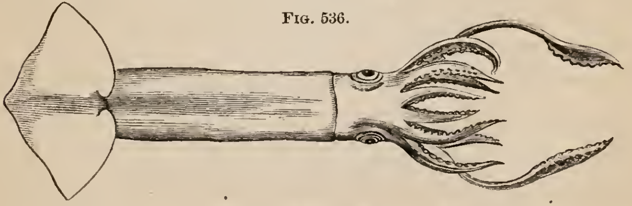
Spirula lævis, Gray. Reduced one half. New Zealand.

FIG. 535.



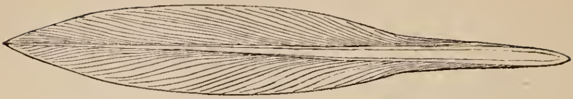
Octopus or Poulpe, *Octopus tuberculatus*, Blainville. Much reduced. Mediterranean.

FIG. 536.



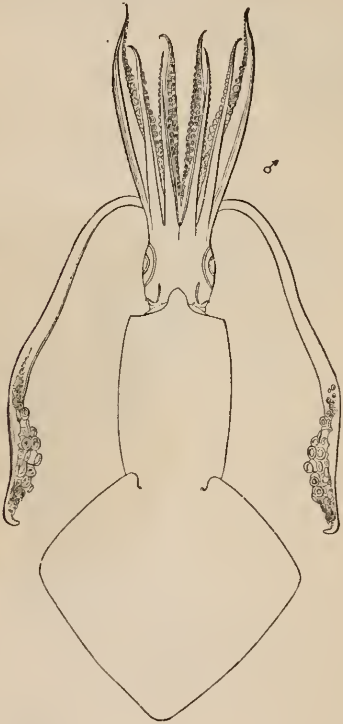
Squid or Loligo, *Loligo Bartramii*, Le Seueur. Much-reduced. Atlantic Coast of United States.

FIG. 537.



"Pen" or "Cuttle-bone" of *Loligo pallida*, Verrill.

FIG. 538.



Loligo pallida, Verrill. Reduced to one-third natural size.

colored pigment-cells; and these animals have the power of effecting such changes in these cells, that the hues of the skin differ from one moment to another.

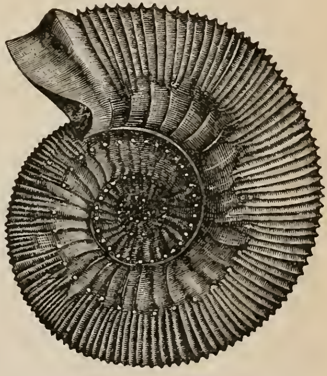
SUB-SECTION III.

THE ORDER OF TETRABRANCHIATA OR FOUR-GILLED CEPHALOPODS.

THE Tetrabranchiata have four branchiæ, and an external chambered shell, and very numerous arms. Their shell is an extremely elongated cone, and is straight, or variously folded, or coiled, and is divided into chambers by partitions called septa, the animal as it grows forming a wall behind itself at regular intervals, and always living in the outer chamber — communicating, however, by a tube or siphuncle with all the others.

The Tetrabranchiates are best known under the name of Chambered Shells. Although only a very few species are now living, more than fourteen hundred species have been found fossil in rocks below the Tertiary, and varying in size from an inch to a yard in diameter.

FIG. 539.

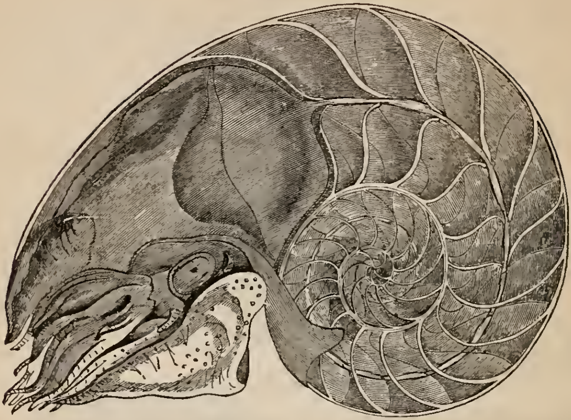


Fossil Chambered Shell—Ammonite.

In the Nautilidæ the siphuncle is central, and the septa simple (Fig. 540).

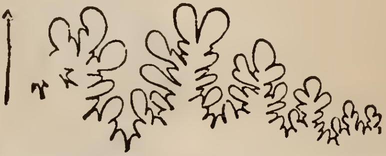
In the Ammonitidæ the siphuncle is dorsal, and the septa are zig-zag, or folded in a very complicated manner (Fig. 541).

FIG. 540.



Pearly Nautilus, *Nautilus pompilius*, Linn. Cut open to show the chambers and siphuncle. Much reduced in size. Pacific and Indian Oceans.

FIG. 541.



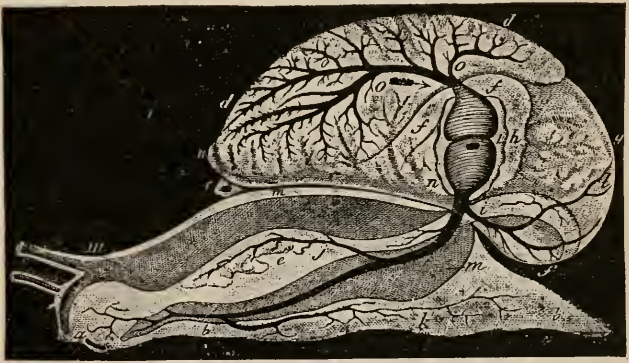
Septum or Suture of an Ammonite.

SECTION III.

THE CLASS OF GASTEROPODA OR GASTEROPODS.

The Gasteropods are mollusks whose ventral side serves them as a sort of foot, by means of which they creep along. The name is from the Greek *gaster*, stomach, and *pous*, a foot. This Class comprises about three-fourths of all the Mollusca.

FIG. 542.



Internal structure of a Gasteropod—Snail.

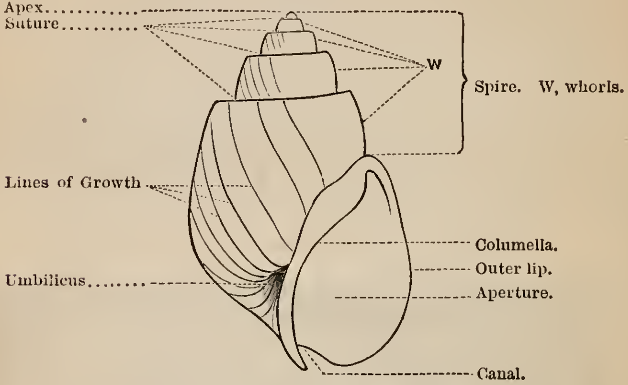
a, mouth; *b*,*b*, the foot; *c*, vent; *d*,*d*, lung; *e*, stomach covered by the salivary glands; *f*,*f*, intestine; *g*, liver; *h*, heart; *i*. aorta; *j*, gastric artery; *l*, hepatic artery; *k*, artery of the foot; *m*,*m*,*m*, abdominal cavity supplying the place of a venous sinus; *n*,*n*, irregular canal connecting the abdominal cavity and the lung; *o*,*o*, vessel carrying the blood from the lung to the heart.

Most of the Gasteropods have a shell; and as this is made of only one piece or valve, they are often called

Univalves. Some, however, have no shell in the adult state, though all have a shell when first hatched.

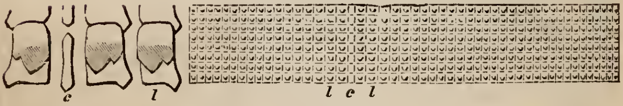
Many kinds of gasteropods have a lid or door, called the *operculum*, with which they close the opening to the shell when they withdraw within. It is a horny plate, sometimes strengthened by shelly matter.

FIG. 543.


Apex
Suture
W
Spire. W, whorls.
Lines of Growth
Columella.
Outer lip.
Aperture.
Umbilicus
Canal.

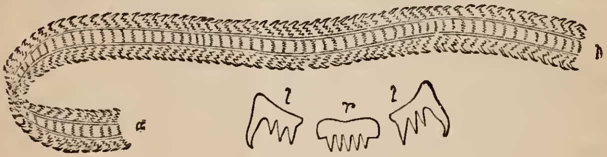
Names of the parts of a Gasteropod Shell.

FIG. 544.



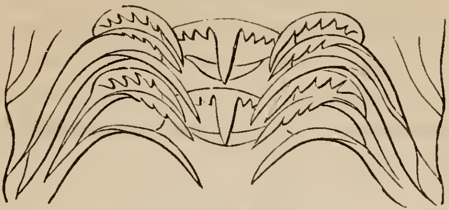
Lingual teeth of *Achatina*, with central and lateral teeth enlarged.

FIG. 545.



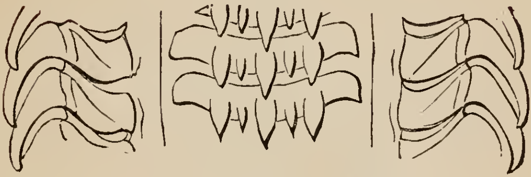
Tongue of the Whelk, *Buccinum undatum*, Woodward.

FIG. 546.



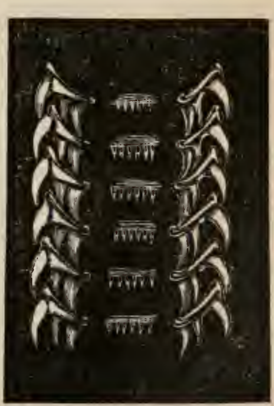
Teeth of *Strombus*, Welton.

FIG. 547.



Teeth of *Murex tenuispina*, Welton.

FIG. 548.

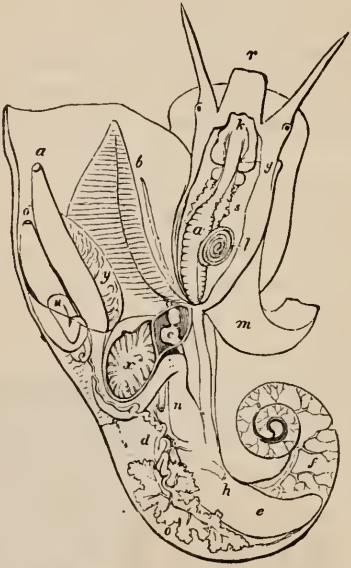


Portion of Tongue of the Whelk, *Buccinum undatum*. Magnified.

One of the most curious parts of these animals is the tongue, or lingual ribbon, which is a band armed with a great number of glossy siliceous teeth, which are arranged in rows in the most regular manner; and differently in the different kinds of gasteropods. The tongue of some kinds contains one hundred and sixty rows of teeth, and one hundred and eighty teeth in each row, or more than twenty-eight thousand in all!

Many of the Gasteropods feed upon vegetable substances, and these generally have the aperture of the shell entire. The others feed upon animal substances, and have the aperture notched, or drawn out into a canal, as in Figs. 551–555. Some kinds feed upon dead animals which they find; others attack living mollusks, and although the latter are shut tightly within their shells, the hungry gasteropod, with its rasp-like tongue, files a neat round hole through the shell, and then leisurely feasts upon its contents. Thus clams and other large mollusks fall a prey even to some of the very small carnivorous gasteropods.

Fig. 549.



Gasteropod, *Littorina littoralis*, removed from its shell, and the back and branchial cavity laid open.

r, muzzle; *k*, buccal mass; *g*, nervous ganglia; *s*, salivary gland; *œ*, œsophagus; *l*, lingual coil; *m*, shell muscle; *b*, branchia; *c*. heart; *n*. aorta; *e*, stomach; *f*, liver; *h*, biliary canal; *i*, intestine; *a*, vent; *o*, ovary; *d*, oviduct; *u*, nidament; *o*, ovarian orifice; *x*, renal organ; *y*, mucous gland.

Gasteropods have a heart—with one auricle and one ventricle—and arteries; but veins are wanting or incomplete.

Some kinds perform their respiration by means of gills, and are called the Branchifera. Others breathe by means of lung-like cavities, and are called the Pulmonifera.

Their nervous system is but little more than a cephalic ganglion and a thoracic ganglion united so as to form a collar around the gullet.

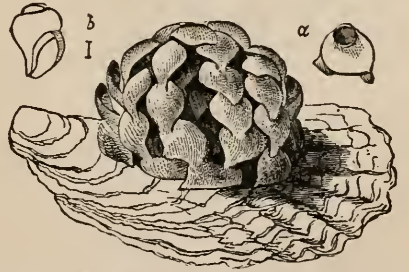
Their two eyes are situated on long stalks.

Their ears are a pair of small membranous vesicles.

The sense of smell and the sense of touch reside in the tentacles.

The Gasteropods lay eggs from which the young are hatched. As already stated, however, on page 392, the River-Snails (*Paludina*) are viviparous. The eggs of the Land-Snails are protected by a flexible shell in some species, and by a brittle shell in others. The eggs of the Fresh-water Snails are soft and transparent. The spawn of some kinds of Sea-Snails is in the form of a band or

FIG. 550.



Nidamental capsules of a Gasteropod—Whelk, *Buccinum*.

a, single capsule showing the hole through which the five or six young escape; *b*, young shell and line indicating its natural size.

ribbon more or less coiled (*Natica.*) The Whelks (*Buccinum*) and other carnivorous gasteropods, produce masses or strings of tough capsules, each containing numerous young.

The Gasteropoda are divided in different ways by different writers, according to the value which they attach to the different parts of their structure.* Five groups or Orders are very generally recognized:

1. PROSOBRANCHIATA (including Pectinibranchiata, etc.) are those with pectinated gills which are situated near the front of the body, as Strombs, etc. The name comes from the Greek *pros*, in front, and *bragchia*, gills.
2. PULMONIFERA or air-breathers; as Land Snails, etc. The name is from the Latin *pulmo*, a lung, and *fero* to bear.
3. OPISTHOBRANCHIATA (including Tectibranchiata and Nudi-

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* One of the most recent classifications is that of Dr. Theodore Gill (see "*Arrangement of the Families of the Mollusks prepared for the Smithsonian Institute*, 1871). Dr. Gill divides the Gasteropoda thus:

Class Gasteropoda or Cephalophora.

Sub-class Diœca.

Order 1. Pectinibranchiata (*Strombus*, etc.).
" 2. Heteropoda (*Carinaria*, etc.).
" 3. Rhipidoglossa (*Nerita*, etc.).
" 4. Docoglossa (*Patella*, etc.).
" 5. Polyplacophora (*Chiton*, etc.).

Sub-class Pulmonifera.

Order 6. Pulmonata (*Helix*, etc.).

Sub-class Opisthobranchiata.

Order 7. Tectibranchiata (*Bulla*, etc.).
" 8. Nudibranchiata (*Doris*, etc.).

Sub-class Pteropoda.

Order 9. Thecosomata (*Hyalea*, etc.)
" 10. Gymnosomata (*Clio*, etc.).

Sub-class Prosocephala.

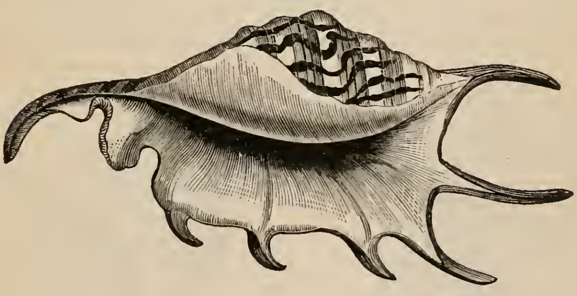
Order 11. Solenoconchæ (*Dentalium*).

branchiata) or gasteropods with the gills on the back and sides and towards the hind part of the body; as Bulla, Aplysia, Doris, Eolis, etc. The name is from the Greek *opisthe,* behind, and *bragchia,* gills.

4. HETEROPODA or Nucleobranchiata, or marine gasteropods with a fin-like tail, or fan-shaped ventral fin provided with a sucker for attachment. They swim rapidly at the surface of the sea. Carinaria is an example. The name Heteropoda comes from the Greek *heteros*, different from others, and *pous*, foot.
5. PTEROPODA or Wing-footed gasteropods of the open sea; as Hyalea, etc. The name is from the Greek *pteron,* a wing, and *pous,* foot.

1. The PROSOBRANCHIATA, as already stated, have pectinated or comb-teeth-like gills situated towards the forward part of the body. They have a mantle forming a chamber over the back of the head; and in this chamber are the excretory orifices, and, in most cases, the gills also. A shell is always present, and into this all the soft parts can be withdrawn.

FIG. 551.



Scorpion-shell, *Pteroceras lambis*, L. Reduced. Chinese Seas.*

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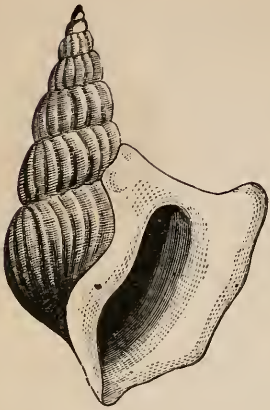
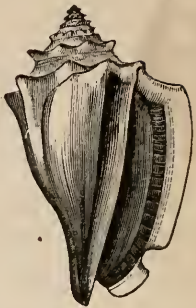
* Foreign shells are quite as likely to fall in the hands of American students as those of our own coast.

FIG. 552.



Aporrhais occidentalis, Beck. New England.

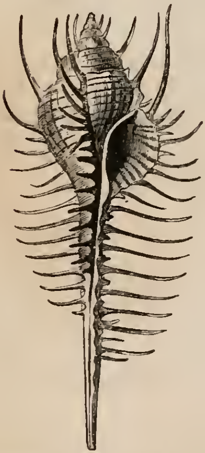
FIG. 553.



Strombus pugilis, L. One half.
West Indies.

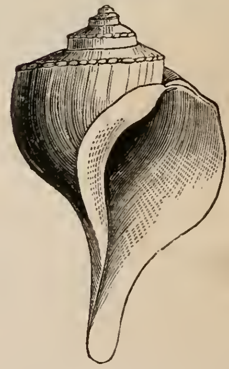
Those prosobranchiates which have the shell with the aperture notched, or prolonged into a sort of canal in

FIG. 554.



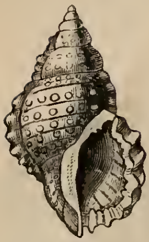
Murex tenuispina, Lamarck.
Reduced.

FIG. 555.



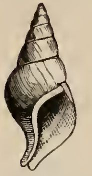
Pyrula canaliculata, Linn. Reduced.
United States.

FIG. 556.



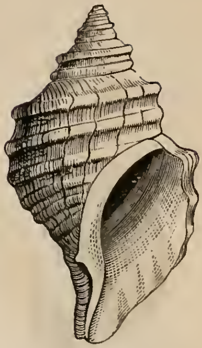
Ranella granifera, Lam. Reduced. Australia.

FIG. 557.



Tritonium pygmæum, Gould. New England.

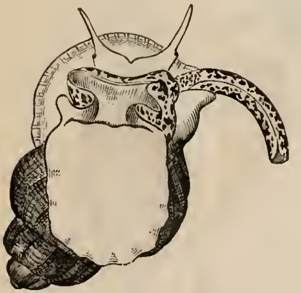
FIG. 558.



Fusus decemcostatus, Say. United States.

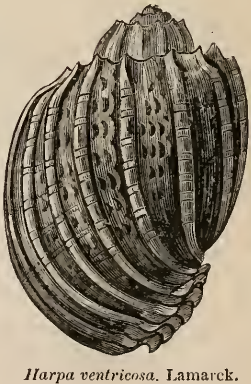
front, are called the Siphonostoma, and are mainly Carnivorous gasteropods. These include the Strombidæ (*Strombus*, *Pteroceras*, etc., Figs. 553, 551); the Muricidæ (*Murex*, *Ranella*, *Tritonium*, *Pyrula*, *Fusus*, etc., Figs. 554, 556, 557, 555, 558); the Buccinidæ (*Buccinum*, *Ri-*

FIG. 559.



Whelk, or *Buccinum undatum*, L. North Atlantic.

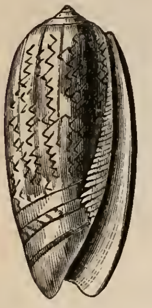
FIG. 560.



Harpa ventricosa. Lamarck. Reduced. Mauritius.

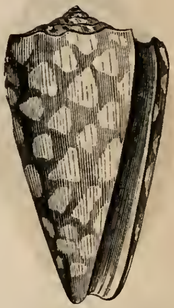
cinula, *Harpa*, *Oliva*, etc., Figs. 559, 563, 560, 561); the Conidæ (*Conus*, etc., Fig. 562); the Volutidæ (*Voluta*, *Mitra*, *Marginella*, etc., Figs. 564, 565); and Cypræidæ (*Cypræa*, *Trivia*, etc., Figs. 566, 567).

FIG. 561.



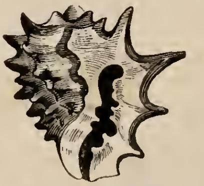
Oliva porphyria, Lamarck. Panama.

FIG. 562.



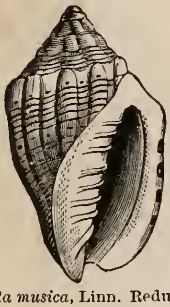
Conus marmoreus, Gmelin. China.

FIG. 563.



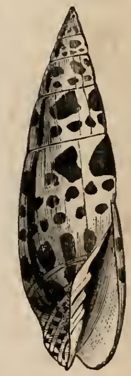
Ricinula arachnoides. China.

FIG. 564.



Voluta musica, Linn. Reduced, West Indies.

FIG. 565.

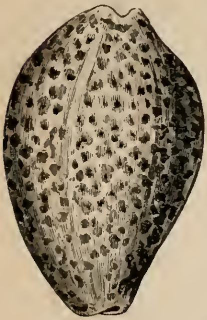


Mitra episcopalis, D'Org. Reduced. Ceylon.

Other prosobranchiates have the margin of the aperture entire, and the operculum horny or shelly, and usually spiral. These are called Holostoma, and are mostly plant-eaters. Some kinds, however, as *Natica*, etc., are carnivorous.

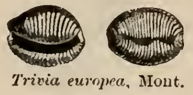
The Holostoma are the Naticidæ (*Natica*, *Sigaretus*, etc., Figs. 571, 570); the Pyramidellidæ (*Pyramidella*, *Chemnitzia*, etc., Fig. 572); the Cerithiidæ (*Cerithium*,

FIG. 566.



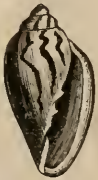
Cypræa. Reduced. Indian Ocean.

FIG. 567.



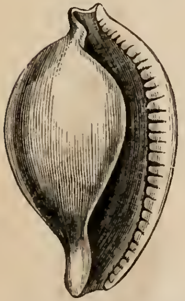
Trivia europea, Mont. Britain.

FIG. 568.



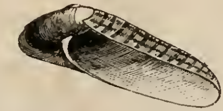
Marginella nubeculata, Lam. Reduced. W. Africa.

FIG. 569.



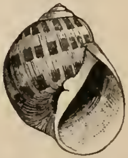
Ovulum ovum, L. Reduced. New Guinea.

FIG. 570.



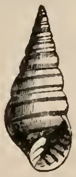
Sigaretus haliotoides, L. West Indies.

FIG. 571.



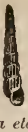
Natica triseriata, Say. Coast of New England.

FIG. 572.



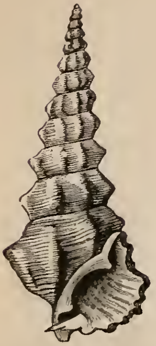
Pyramidella dolobrata, Gmel. West Indies.

FIG. 573.



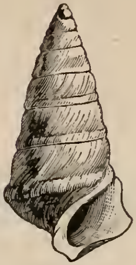
Pyramidella elegantissima, Mont. Reduced. Britain.

FIG. 574.



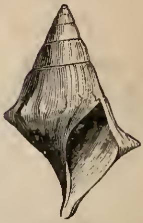
Cerithium nodolosum, Brug. Reduced. Molucca.

FIG. 575.



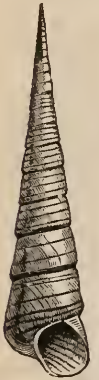
Melania. Western States.

FIG. 576.



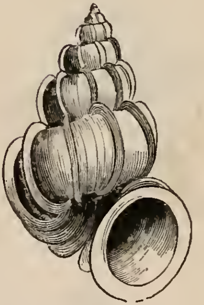
Io. Southern States.

FIG. 577.



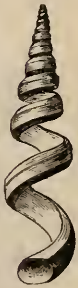
Turritella imbricata, L. West Indies.

FIG. 578.



Scalaria pretiosa, Lam. Reduced. China,

FIG. 579.

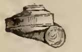


Vermetus lumbricalis, Gm. West Indies.

etc., Fig. 574); the Melaniadæ (*Melania*, etc., Fig. 575); the Turritellidæ (*Turritella*, *Scalaria*, etc., Figs. 577, 578); the Littorinidæ (*Littorina*, etc., Fig. 583); the Paludinidæ (*Paludina*, etc., Fig. 582); the Neritidæ (*Nerita*, *Neritina*, etc., Figs. 585, 584); the Turbinidæ

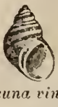
(*Turbo*, *Trochus*, etc., Fig. 586); the Haliotidæ (*Haliotis*, *Janthina*, etc., Fig. 587, 588); the Fissurellidæ (*Fissurella*, etc., Fig. 591); the Calyptræidæ (*Calyptræa*, *Crepidula*, etc., Fig. 589, 592); the Patellidæ (*Patella*, *Acmæa*, etc., Fig. 590); the Dentalidæ (*Dentalium*, Fig. 594); and the Chitonidæ (*Chiton*, Fig. 593).

Fig. 580.



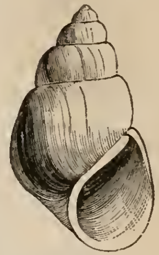
Valvata tricarinata, Say.
United States.

Fig. 581.



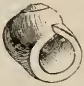
Lacuna vincta.
North Atlantic.

Fig. 582.



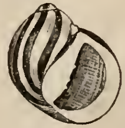
Paludina integra, Say.
United States.

Fig. 583.



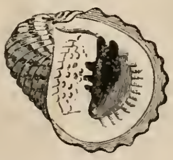
Littorina palliata, Say.

Fig. 534.



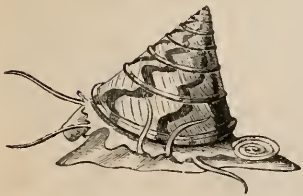
Neritina zebra, Brug.
Pacific.

Fig. 585.



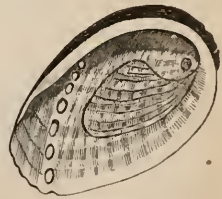
Nerita ustulata, L.
Scinde.

Fig. 586.



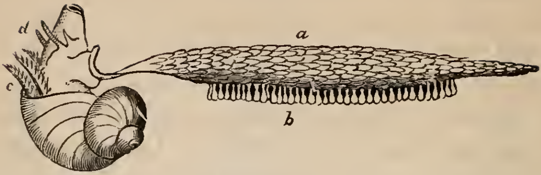
Trochus zizyphinus, L. Britain.

Fig. 587.



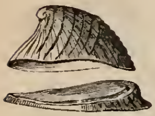
Haliotis tuberculata, L.
Britain.

FIG. 588.



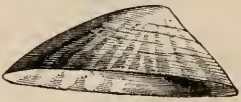
Ianthina fragilis, Lamarck. Atlantic.
a, raft; *b*, egg capsules; *c*, gills; *d*, tentacles and eye-stalks.

FIG. 589.



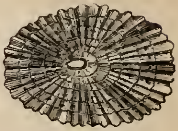
Calyptræa equestris, L.
Philippines.

FIG. 590.



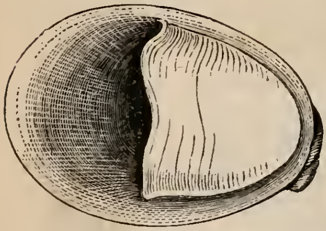
Patella testudinalis, Müller.
New England.

FIG. 591.



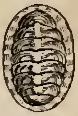
Fissurella Listeri.
West Indies.

FIG. 592.



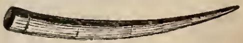
Crepidula fornicata, Say.
New England.

FIG. 593.



Chiton ruber, L. New England.

FIG. 594.

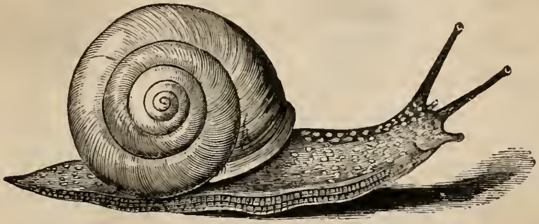


Dentalium dentalis, L.
Atlantic.

2. The PULMONIFERA, as already indicated, on page 406, are the Land-Snails and other gasteropods which are provided with a lung-like organ, formed for breathing air. This organ is a cavity or chamber lined with a net-work of respiratory vessels. The orifice leading to this lung-like organ is small and valve-like; this prevents the too rapid drying in the land species, and prevents the ingress of water in the aquatic species. Unlike the Sea-Snails, the sexes are united in each individual.

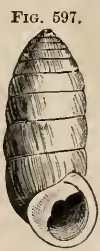
As already implied, most of the Pulmonifera inhabit the land, but some, as *Limnæa*, *Planorbis*, *Physa*, etc. (Figs. 602, 601, 600), abound in fresh waters. Some kinds have no operculum; these are the Helicidæ (*Helix*, *Succinea*, *Bulimus*, *Achatina*, *Pupa*, *Clausilia*, etc., Figs. 595, 598, 596, 597), the Limacidæ (*Limax*, etc., Fig. 599), the Oncidiadæ (*Oncidium*, etc.) the Limnæidæ (*Limnæa*, *Physa*, *Planorbis*, etc., Figs. 601–603), and the Auriculidæ (*Auricula*, etc.).

FIG. 595.



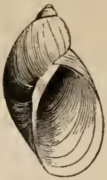
Helix albolabris, Say. United States.

FIG. 597.



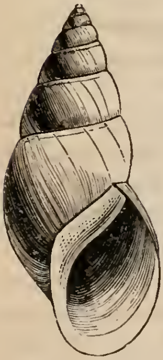
Pupa incana, Say.
Florida.

FIG. 598.



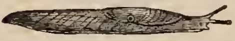
Succinea obliqua, Say.
Western States.

FIG. 596.



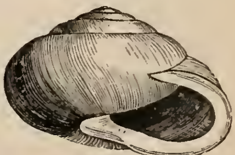
Bulimus excelsus, Gould.
California.

FIG. 599.



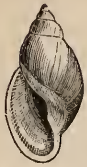
Slug, or *Limax campestris*,
New England.

FIG. 600.



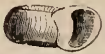
Helix albolabris, Say.

Fig. 601.



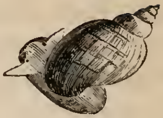
Physa heterostropha, Say.
United States.

Fig. 602.



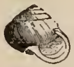
Planorbis lentus, Say.
United States.

Fig. 603.



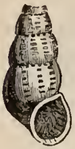
Limnæa desidiosa, Say.
United States.

Fig. 604.



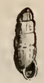
Helicina orbiculata, Say.
United States.

Fig. 605.



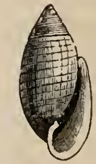
Cyclostoma dentatum.
United States.

Fig. 606.



Acicula fusca
Britain.

Fig. 607.

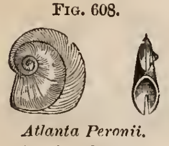


Tornatella tornatilis.
Britain.

Some of the families of the Pulmonifera are provided with an operculum. These are the Cyclostomidæ (*Cyclostoma*, *Helicina*, etc., Figs. 605, 604), and the Aciculidæ (*Acicula*, etc., Fig. 606).

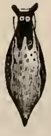
3. The Opisthobranchiata are gasteropods whose gills are more or less branched or fasciculated, and placed towards the hind part of the body. The sexes are united in each individual. In most cases the shell is only rudimentary, or wholly wanting; but some kinds, as *Tornatella*, etc. (Fig. 607), have the shell as well developed as

Fig. 608.



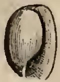
Atlanta Peronii.
South Atlantic.

Fig. 609.



Elysia viridis, Mont.
Britain.

Fig. 610.



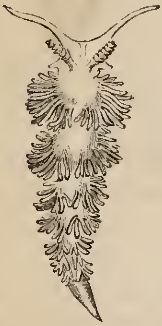
Bulla solitaria, Say.
United States.

in other gasteropods; and others, as *Bulla*, etc. (Fig. 610), have the shell fully formed, but very thin.

One great division of the Opisthobranchiates is called Tectibranchiata, because the branchiæ are covered by the shell, or mantle. These are the Tornatellidæ (*Tornatella*, *Ringicula*, etc., Fig. 607), the Bullidæ (*Bulla*, etc., Fig. 610), the Aplysiadæ (*Aplysia*, etc.) the Pleurobranchidæ (*Pleurobranchus*, etc.), and the Phyllidiadæ.

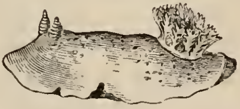
Other Opisthobranchiates are called Nudibranchiata, because their gills, situated on the back or sides of the

Fig. 611.



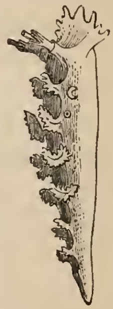
Æolis coronata, Forbes. Britain.

Fig. 612.



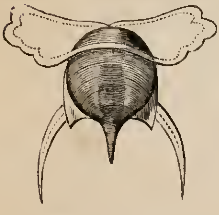
Doris Johnstoni, Alder & Hancock. Britain.

Fig. 613.



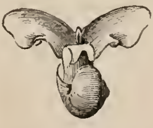
Tritonia plebeia, Johnston. Britain

Fig. 614.



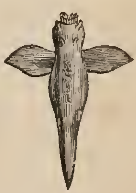
Hyalea tridentata, Gmel. Atlantic and Mediterranean.

Fig. 615.



Limacina antarctica, Hooker. South Polar Seas.

Fig. 616.



Clio borealis, Brug. Arctic Seas.

body, are wholly uncovered. These are the Doridæ (*Doris*, etc., Fig. 612), the Tritonidæ (*Tritonia*, etc., Fig. 613), the Æolidæ (*Æolis*, etc., Fig. 611), the Elysiadæ (*Elysia*, etc.), etc.

4. The Heteropoda or Nucleobranchiata include the Firolidæ (*Firola*, *Carinaria*, etc.), and the Atlantidæ (*Atlanta*, etc., Fig. 608). These, as before indicated on p. 407, are marine gasteropods, which have the "foot" so modified as to be a fin-like tail, or fan-shaped ventral fin, by means of which they swim at the surface of the sea. They are called Nucleobranchs because their respiratory organs are in the form of a sort of nucleus.

5. The Pteropoda—by some regarded as a Class, and by others as a Sub-class—have their locomotive organ so modified as to appear like wings. These curious mollusks live in the open sea, moving in immense swarms. They include the Hyaleidæ (*Hyalea*, etc., Fig. 614), the Limacinidæ (*Limacina*, etc., Fig. 615), and the Cliidæ (*Clio*, etc., Fig. 616).

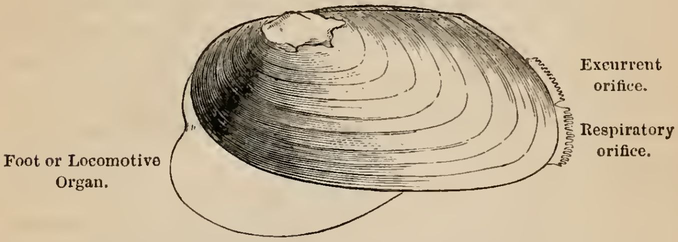
The two first-named families—Hyaleidæ and Limacinidæ—are the Thecosomata of authors, so called because some of the genera have a shell—from the Gr. *theke*, a case, and *soma*, body. And the last-named family—Cliidæ—is the group called Gymnosomata, because the animal is naked, or without a shell—from the Gr. *gumnos*, naked, etc.

SECTION IV.

THE CLASS OF ACEPHALA OR LAMELLIBRANCHIATA OR BIVALVES.

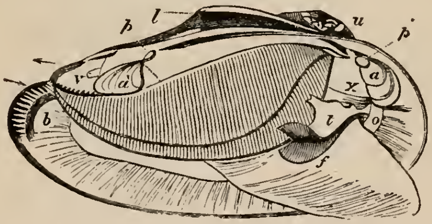
The mollusks of this Class seem to have no head, this important part of the animal being but little developed, and wholly concealed within the mantle, and the whole covered with a shell composed of two pieces called valves. The valves are joined together by a hinge, and held

Fig. 617.


Excurrent orifice.
Respiratory orifice.
Foot or Locomotive Organ.

An Acephal—Fresh-water Mussel. *Unio complanatus*, Lea, U. S.

Fig. 618.

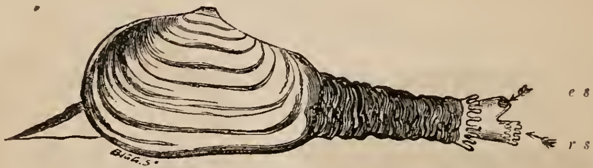

p
l
u
p
v
a
a
x
b
t
o
f

Internal Structure of a Fresh-water Mussel, *Unio pictorum*, L., with the right valve and mantle lobe removed.

a, *a*, adductor muscles; *p*, *p*, pedal muscles; *x*, accessory pedal muscles ; *u*, umbo ; *l*, ligament ; *b*, branchial orifice ; *v*, anal opening ; *f*, foot ; *o*, mouth ; *t*, tentacles or palpi.

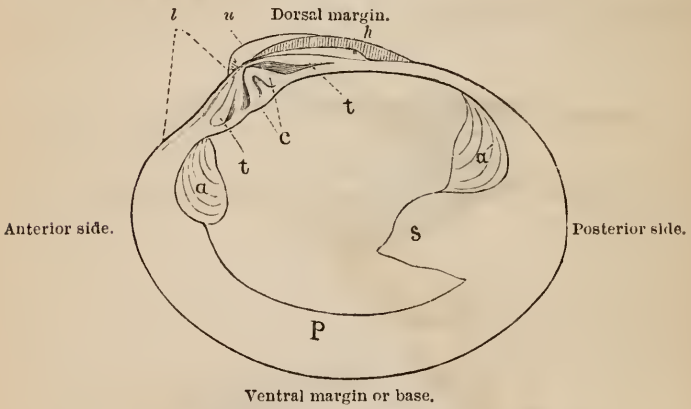
tightly shut by one or two strong muscles called adductors (Fig. 620, *a*, *a'*). When the animal relaxes these muscles the shell is opened by an elastic pad or ligament situated at the hinge (Fig. 620, *h*).

FIG. 619.



An Acephal—Clam, *Mya truncata*, L. Reduced one-half.
rs, respiratory tube or siphon ; the water flows into the branchial chamber, through this tube, and out through the excurrent siphon *es*.

FIG. 620.

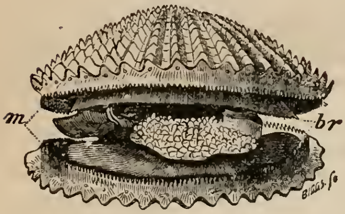


Names of the parts of a Bivalve Shell.
a, place of anterior adductor muscle ; *a'*, place of posterior adductor muscle ; *t*, lateral teeth ; *c*, cardinal tooth ; *l*, lunule ; *u*, umbo ; *h*, hinge ligament ; *s*, sinus occupied by the retractor muscles of the siphons ; *p*, pallial impression or place of the attachment of the mantle.

The Acephals abound in both salt and fresh waters; and living as well as dead specimens are always easily obtained for study. Every student can obtain either an Oyster

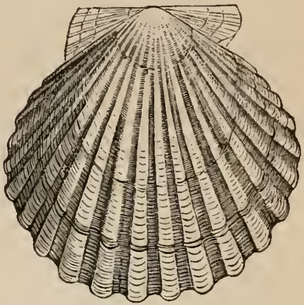
(Fig. 626), a Clam (Figs. 619 and 636), a Fresh-water Mussel (Figs. 617 and 618), a Scallop (Fig. 622), or some other form; and a careful study of one will give a general idea of all the ordinary kinds.

Fig. 621.



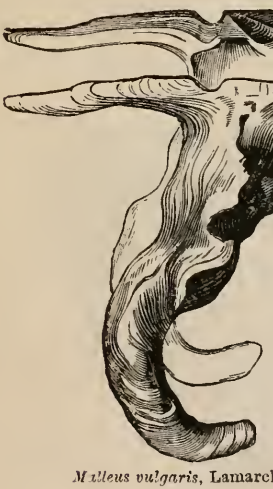
An Acephal. Scallop, *Pecten varius*, L. *m*, pallial curtains; *br*, branchiæ.

Fig. 622.



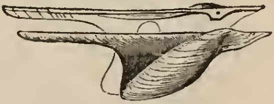
Pecten irradians, Lam. Reduced. From Cape Ann southward.

Fig. 623.



Malleus vulgaris, Lamarck. China.

Fig. 624.

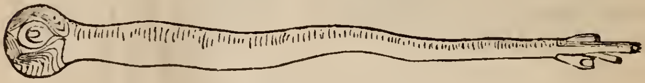


Avicula hirundo, L. Reduced. Mediterranean.

The forms of Acephala or Lamellibranchiata are very numerous, and widely varied from one another. Some kinds have much of regularity in their outline (Figs. 620, 622). Others arrest our attention by their great irregularity of form and the peculiarities of their surface (Figs. 623, 624, 628, etc.).

Most kinds have the shell well developed, but some kinds, as Teredo and Aspergillum, have the shell exceedingly small in comparison with the size of the animal.

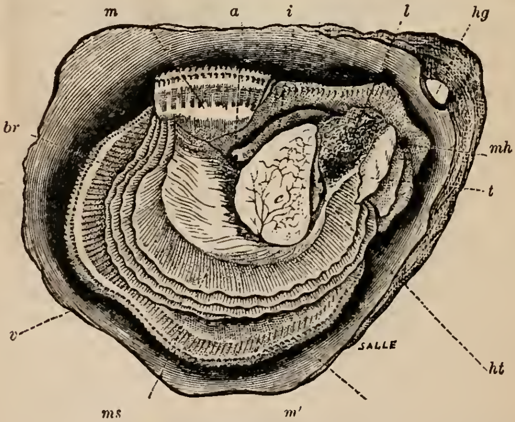
FIG. 625.



"Ship-worm," *Teredo norvegica*, removed from its burrow.

The structure of the Acephals or Lamellibranchiates, will be better understood by referring to Figs. 618, 626–7.

FIG. 626.



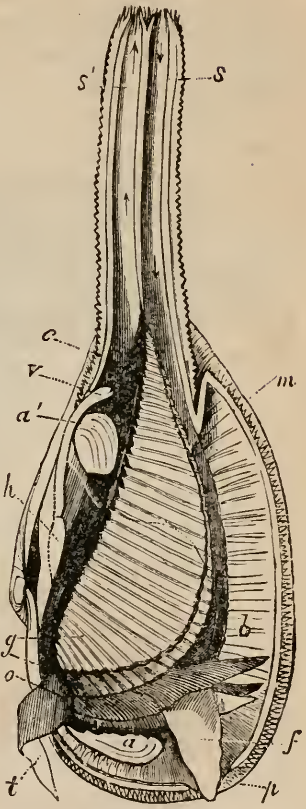
Internal structure of the Oyster.

v, one valve of the shell; *hg*. hinge; *m*, one of the lobes of the mantle, and *m′*, portion of the other lobe turned upward; *ms*, muscles of the shell; *br*, branchiæ or gills; *mh*, mouth; *t*, labial tentacles; *t*, liver; *i*, intestine; *a*, anus; *ht*, heart.

The mouth is situated at the anterior side or end; it has no teeth, but has two pairs of labial tentacles. The stomach, intestine, and liver are well developed. The heart has one auricle—in some cases divided into two—and one ventricle, and the intestine passes through it. The gills or branchiæ consist of two pairs of delicate and finely-striated membranous plates situated just beneath the mantle. The gills not only serve for the processes of respiration, but by means of their vibratile cilia they waft currents of water bearing food to the mouth, and they form a place for the hatching of the eggs.

Most of the Acephals effect locomotion by means of the muscular "foot," which in many species is very large and powerful; and in the boring species, as *Pholas*, *Teredo*, etc. (Figs. 632–4), it is studded with siliceous particles. Some kinds, as fresh-water

FIG. 627.



The rows of dark spots at the base of the gills are the orifices of the branchial tubes opening into the dorsal channels.

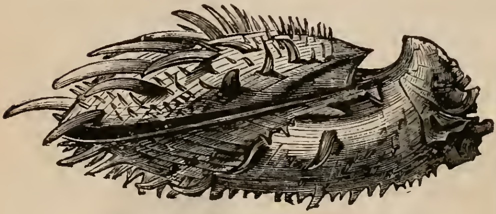
Clam, *Mya arenaria*, L.—The left valve, mantle lobe, and half the siphons removed.

h, heart; *m*, cut-edge of the mantle; *o*, mouth; *s*, siphon into which the water flows to bathe the gills and to carry particles of food; *s'*, siphon which carries the outflowing current; *t*, labial tentacles; *v*, vent.

a, *a'*, adductor muscles; *b*, body; *c*, cloaca; *f*, "foot"; *g*, gills or branchiæ.

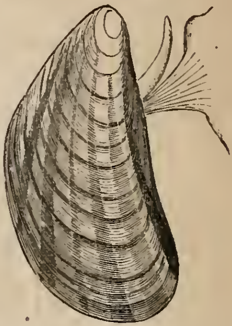
Mussels, etc., move by protruding the foot and then contracting it; and others, as *Cardium*, *Trigonia*, etc., have the foot so bent that they can make short leaps. The Pectens (Fig. 622), however, move by opening and shutting the valves of the shell, and ejecting the water caught between the valves, and thus forcing themselves along.

FIG. 628.



Thorny Oyster, *Spondylus avicularis.*

FIG. 629.

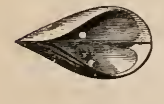


Mytilus edulis, L. Reduced
Both shores of the Atlantic

And it should be added here, that some kinds are constantly fixed in their adult state, the Sea-Mussel and Pinna being attached by threads, which they spin, and which are called a byssus (Fig. 629); and the Oyster and Spondylus being attached by leafy expansions, or by spines of their shell (Fig. 628).

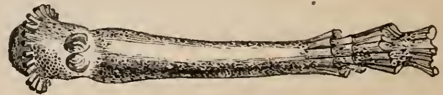
Bivalves reproduce by means of eggs, and are exceedingly prolific, some kinds, as the Mussels and Oysters,

FIG. 630.



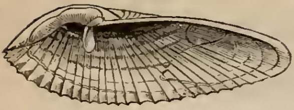
Gastrochæna modiocena,
Lam. Galway.

FIG. 631.



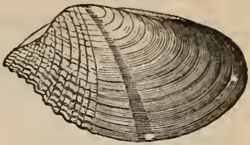
Aspergillum vaginiferum, Lam. Reduced. Red Sea.

FIG. 632.



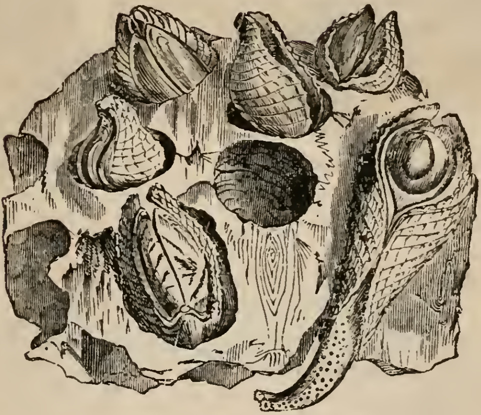
Pholas Bakeri, Desh. Reduced.
India.

FIG. 633.



Pholas crispata, Linn.
New England and eastward.

FIG. 634.



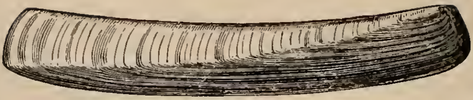
Boring Bivalves, *Pholas*.

producing 200,000 or 300,000 young in a season. The eggs are hatched before they leave the parent; and the young of all species are very different from the parent, and are swimmers, and have a pair of eyes in the normal position. Bivalves grow rapidly, some kinds getting their full growth in a single year.

The nervous system consists of two pairs of small ganglia, one at the anterior and the other at the posterior end, united by nervous cords or filaments.

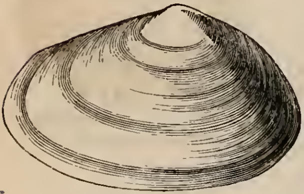
Naturalists generally recognize two great divisions of the Acephals: 1. DIMYARIA (from the Gr. *dis*, two, and

FIG. 635.



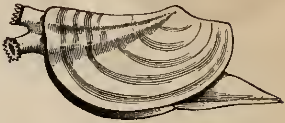
Solen ensis, Linn. Much Reduced. Atlantic.

FIG. 636.



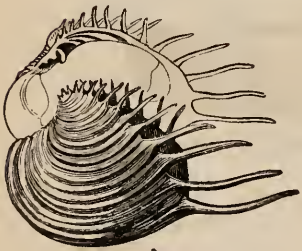
Mya arenaria, L. Reduced.
Northern States.

FIG. 637.



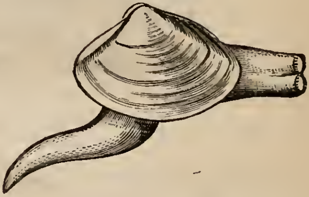
Pandora obtusa, Britain.

FIG. 638.



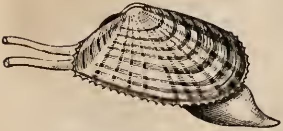
Cytherea dione, L. Reduced.
West Indies.

FIG. 639.



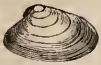
Mactra elliptica. Britain.

FIG. 640.



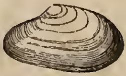
Tellina donacina. Britain.

FIG. 641.



Tellina tenera, Say.
Our coast.

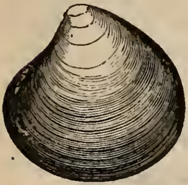
FIG. 642.



Tellina tenta, Say.
Our coast.

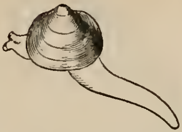
mus, muscle), or those whose shell is closed with two muscles, as in the Clam (*Mya*), etc., and, 2. MONOMYARIA (from the Gr. *monos*, one, and *mus*, muscle), or those whose shell is closed by one muscle, as the Oyster, etc.

FIG. 643.



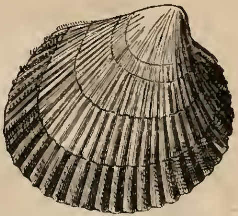
Astarte castanea, Say.
Casco Bay and southward.

FIG. 644.



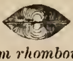
Sphærium partumeium, Say. Northern States.

FIG. 645.



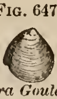
Cardium islandicum, Linn.
North Atlantic.

FIG. 646.



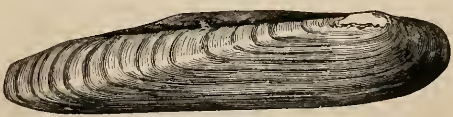
Sphærium rhomboideum, Say.
Northern States.

FIG. 647.



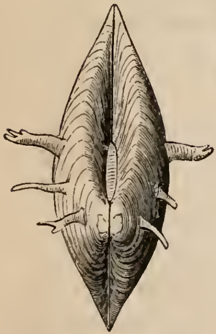
Thyasira Gouldii, Stim.
Coast of New England.

FIG. 648.



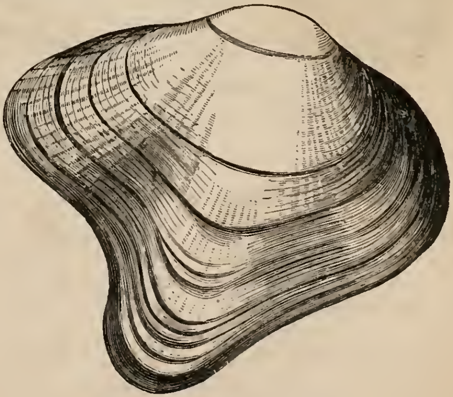
Unio Shepardianus, Lea. Southern States.

FIG. 649.



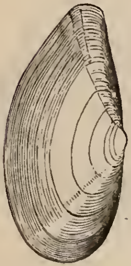
Unio spinosa, Lea. Reduced.
Georgia.

FIG. 650.



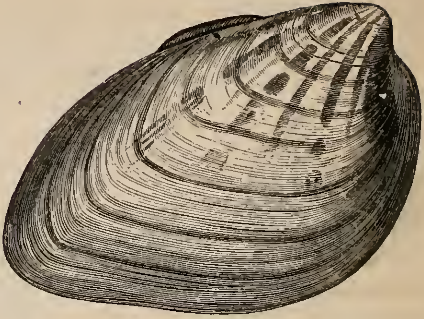
Unio flexuosus, Raf. Reduced.
Western States.

FIG. 651.



Leda limatula. New England.

FIG. 652.



Unio clava, Lam. Reduced. Western States.

A more recent classification, that of Dr. Gill, in the paper cited on page 406, recognizes five Orders:

1. DIMYARIA, as *Aspergillum, Gastrochæna, Teredo, Pholas, Solen Mya, Pandora, Mactara, Tellina, Cytherea, Astarte, Cardium, Unio, Leda,* etc., etc.
2. METARRHIPTÆ, as *Tridacna,* etc.
3. HETEROMYARIA, as *Mytilus,* etc.
4. MONOMYARIA, as *Pinna, Spondylus, Malleus, Pecten, Ostrea,* etc.
5. RUDISTA—Coral-like mollusks—all fossil.

SECTION V.

THE CLASS OF TUNICATA OR ASCIDIANS.

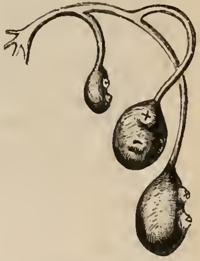
The Tunicata are one of the great groups of mollusk-like animals which authors include in the Sub-branch of Molluscoidea.

They are exceedingly unlike typical mollusks in their general appearance, and very unlike them in many points in their structure. Gegenbaur classes them with the Vermes.

The Tunicates are more or less bottle-shaped or pouch-like, and attached to submarine bodies, are entirely destitute of hard parts, being covered by an elastic tunic, instead of a shell, and some kinds are so transparent as to exhibit plainly their internal structure.

Some kinds are simple and solitary; others live together in communities; and others still are compound clusters (Fig. 653).

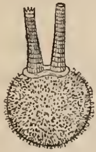
FIG. 653.



Tunicates.

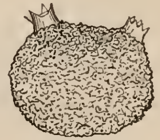
A compound cluster of Tunicates or Ascidians, *Boltenia*. Reduced.

FIG. 654.



Tunicate, *Eugyra pilularis*, Verrill.

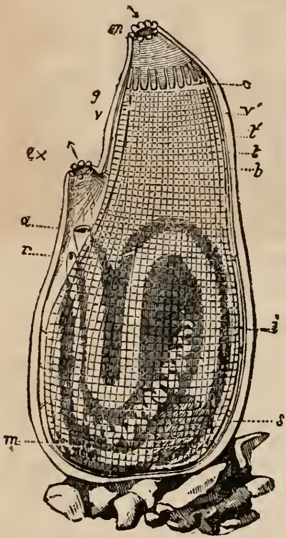
FIG. 655.



Tunicate, *Molgula arenata*, Stimpson.

They are hollow, and have two orifices, one for the ingress of water and food, and another for the egress of water and the waste of the body.

Fig. 656.



Tunicate, *Ascidium monachus*.
in, incurrent orifice; *ex*, excurrent orifice; *t'*, outer tunic; *t*, inner tunic, composed of crossing muscular fibers; *b*, branchial sac; *o*, tentacular fringe; *g*, nervous ganglion; *vv'*, dorsal and ventral sinuses; *m*, mouth at the bottom of the branchial sac; *s'*, stomach plaited lengthwise; *i*, intestine; *a*, termination of the intestine; *r*, reproductive organ.

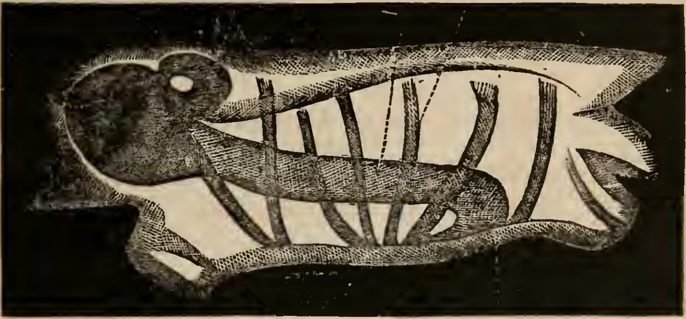
In most genera of the Tunicata the sexes are united, and reproduction is carried on by means of eggs, and by a budding process or gemmation.

The larvæ of Ascidians are tadpole-like in shape, and move freely about in the water. It is claimed that they are related to the Vertebrates in their mode of development, in the relative position of their nervous system, and in possessing a structure closely like the *chorda dorsalis* of vertebrated animals. And according to Darwin, the Vertebrates may have been derived from animals resembling the larvæ of our present Ascidians!

The tunicates, which are called Salps or Salpidæ, are remarkable from the fact that the generations are alternately solitary and aggregated.

That is, the Salps produce long chains of embryos wholly unlike the parent. Each individual of these compound specimens produces solitary young wholly unlike the parent, but like the grandparents. And these solitary salps produce, in turn, long chains of embryos—and so on; only the alternate generations being alike.

FIG. 657.



Biphora or Salp.

Salpa maxima, Forskahl. The flat bands are muscular tissue.

Some kinds of tunicates, as the Pyrosomes or Pyrosomidæ—which live in cylinder-shaped compound communities—are remarkable for their phosphorescence at night, sometimes resembling "incandescent cylinders of iron."

Dr. Gill, in the paper already cited, recognizes four Orders of the Tunicata:

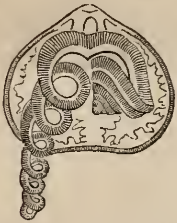
1. SACCOBRANCHIA, as *Ascidium, Boltenia, Clavellina, Botryllus,* etc.
2. DACTYLOBRANCHIA, as *Pyrosoma.*
3. TÆNIOBRANCHIA, as *Salpa*, etc.
4. LARVIALIA, as *Appendicularia.*

SECTION VI.

THE CLASS OF BRACHIOPODA OR BRACHIOPODS.

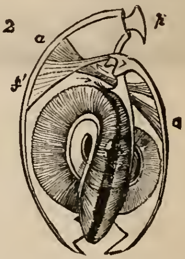
The Brachiopoda get their name from the two long ciliated arms growing from the sides of the mouth, by means of which they create currents in the water and thus secure their food. The name—from the Gr. *brachion*, an arm, and *pous*, a foot—means arm-footed.*

FIG. 658.



Brachiopod—dorsal valve with soft parts.

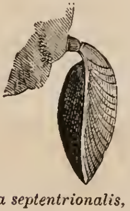
FIG. 659.



Brachipod—ideal side view.

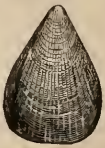
All the Brachiopods are marine, and are found, mostly,

FIG. 660.



Terebratula septentrionalis, Couth.

FIG. 661.



Terebratula septentrionalis, Couthouy. Small specimen. New England and northward.

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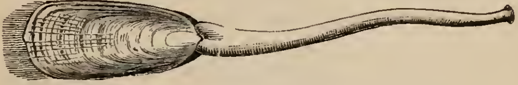
* There is a doubt as to the true affinities of the Brachiopods. Professor Morse and many others regard them as Articulates (see foot note p. 370).

in deep water, hanging from shelving rocks and from coral banks. Some kinds, as Lingula, are found living on or in the sands, in shallow water.

Fig. 662.

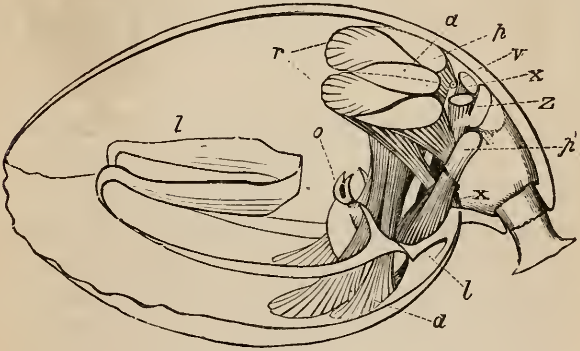


Lingula anatina, Lam. Reduced. Philippines.

There are nearly a hundred living species; and more than twelve hundred species have been found in the rocks, from the Silurian to the Present.

Fig. 663.

Ventral valve.

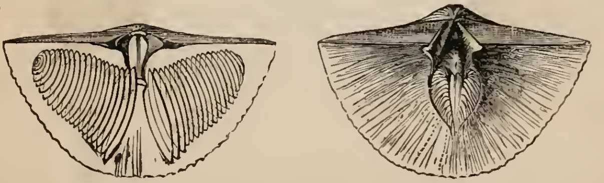


Dorsal valve.

Muscular system of a Brachiopod—*Terebratula*.

a, adductor muscles; *v*, cardinal muscles; *x*. accessory muscles: *p*, ventral pedicle muscles; *p'*, dorsal pedicle muscles; *z*, capsular muscles; *o*, mouth; *v*, vent; *l*, loop; *t*, dental socket.

Fig. 664.



Dorsal valve

Ventral valve.

Fossil Brachiopod—*Spirifera striata*, Sowerby. The dorsal valve, showing spiral processes for the support of the oral arms.

The shell of the Brachiopods is composed of two valves, and occupies a dorsal and ventral position in relation to the body of the animal.

The valves are of unequal size, the dorsal being the smaller, and the ventral valve the larger.

The dorsal valve is always free, and not perforated; the ventral has a more or less prominent beak, through which passes a fleshy peduncle, by means of which the animal is attached to submarine bodies.

Unlike the shells of the typical mollusks, the valves are symmetrical in shape, the two sides being alike.

The two valves are articulated by two curved teeth developed from the margin of the ventral valve, and received by sockets in the dorsal, making a hinge so complete that the two valves cannot easily be separated.

The Brachiopods are divided by naturalists into two Orders:

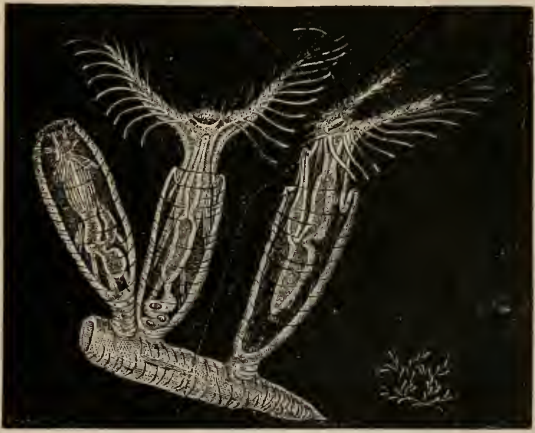
1. ARTHROPOMATA, as *Terebratula, Spirifer,* etc.
2. LYOPOMATA, as *Lingula, Discina,* etc.

SECTION VII.

THE CLASS OF POLYZOA OR BRYOZOA OR MOSS-LIKE MOLLUSKS.*

The Bryozoa are small or minute mollusks growing in clusters, and are exceedingly plant-like in their general appearance. Some kinds belong to the sea, and are found upon rocks, shells, and seaweeds. Others are confined to fresh water ponds and streams, and are found attached to sticks, and sunken logs, and to rocks and other bodies beneath the surface of the water.

Fig. 665.



Plumatella.

p, Plumatella natural size; *P*, Plumatella magnified; *i*, termination of the intestine.

One of the most remarkable things in the structure of the marine bryozoa is that called "birds' heads." In some

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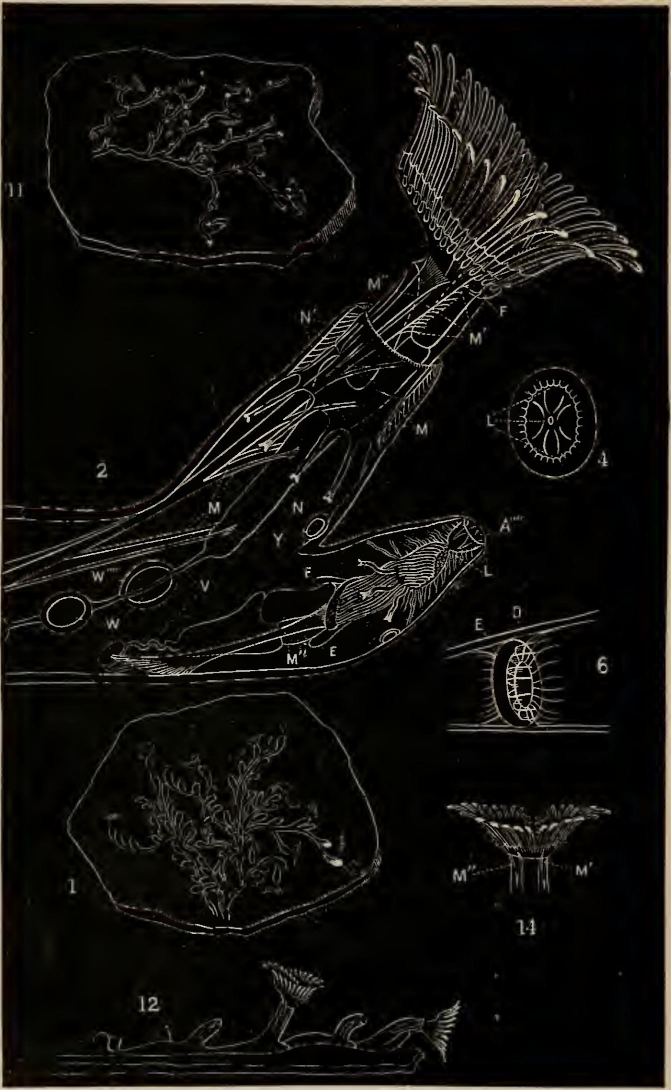
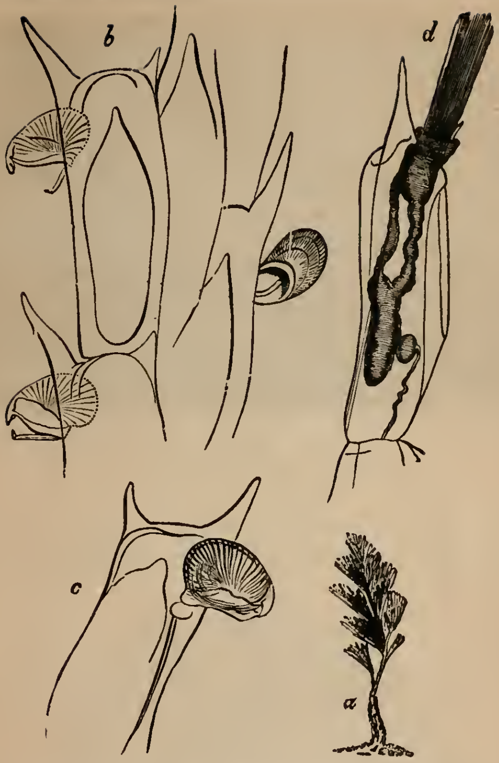
* Packard and others regard the Polyzoa as worms.

FIG. 666.


11
M'''
N'
F
M'
M
L
4
2
M
N
A''''
Y
L
W''''
F
V
W
D
E
6
M''
E
M''
M'
14
1
12

Fresh-water Polyzoa or Bryozoa, natural size, and magnified.
1–6, *Plumatella arethusa*, Hyatt ; 11–14, *P. diffusa*, Hyatt. (From Observations on Polyzoa, by Alpheus Hyatt.)

FIG. 667.

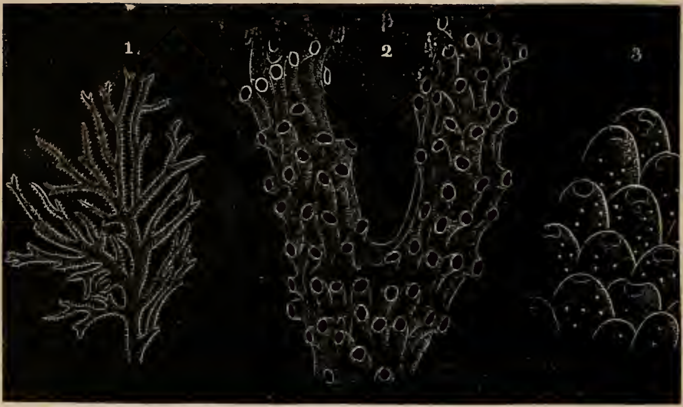


Bryoza, *Cellularia avicularia.*
a, natural size of a growing cluster; *b* and *c*, portions much magnified; *d*, bryozoan in its cell.

species every cell has its "birds' head" (Fig. 667), and this structure is exceedingly active, opening, shutting, and snapping almost continually.

Many of the marine kinds produce coral; and patches of this substance are common on stones, shells, and sea-weeds. These delicate patches of coral are composed

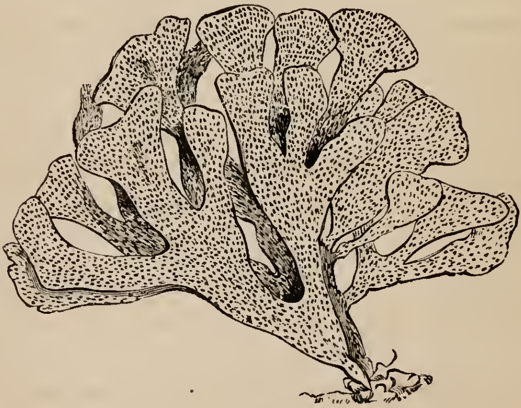
FIG. 668.



Bryozoa.
1. *Hornera lichenoides ;* 2. Portion of the same enlarged.
3. *Discopora Skenei*, enlarged.

of minute cells, and present a very beautiful appearance when examined by means of a magnifying glass.

FIG. 669.



Sea-Mat, *Flustra foliacea*.

The "Sea-mats" are also communities of the Bryozoa. Each side is covered with cells of a somewhat horny nature, and each cell marks the place of a bryozoan.

The Polyzoa comprise two orders:

PHYLACTOLÆMATA (from the Gr. *phulaktos*, guarded, and *laimos*, throat), or those in which the entrance to the throat is guarded by an epistome, as *Pectinella, Cristatella, Plumatella,* and *Pedicellina,* etc.

2. GYMNOLÆMATA (from the Gr. *gumnos*, naked, and *laimos*, throat), or those in which the opening to the gullet is uncovered, as *Paludicella, Escharida, Flustra,* etc.

PRINCIPAL TOPICS CONSIDERED IN CHAPTER IV.

SECTION I.

The Mollusca considered as a Branch.——Their form, structure, habits, uses, etc. ——Classification.

SECTION II.

SUB-SECTION I.

The Cephalopoda considered as a Class.——Their form, structure, size, habits, etc.

SUB-SECTION II.

The Dibranchiata—including the Argonaut, Octopus, Cuttle Fishes, etc.—defined.

SUB-SECTION III.

The Tetrabranchiata defined.——Nautilidæ.——Ammonitidæ.

SECTION III.

The Gasteropoda considered as a Class.——Shell.——Operculum.——Teeth. ——Internal Structure.——Reproduction.

1. Prosobranchiata.——2. Pulmonifera.——3. Opisthobranchiata.——4. Heteropoda.——5. Pteropoda.

SECTION IV.

The Acephala or Lamellibranchiata or Bivalves considered as a Class.——Their external form, internal structure, and functions of the various parts.——Classification.

Sections V., VI., and VII. treat, respectively, of the Tunicata, Brachidpoda, and the Polyzoa or Bryozoa,——their form, structure, etc.

CHAPTER V.

THE BRANCH OF RADIATA OR RADIATES.

SECTION I.

THE RADIATA CONSIDERED AS A BRANCH.

In all the animals of the preceding branches we have found an anterior end and a posterior end, a right side and a left side, an upper side and a lower side, more or less plainly marked.

But the Radiates are so constructed that, apparently, they have no forward end, no posterior end, no right side no left side; but all their parts radiate from a center, or, rather, from a central axis. In a word, they are animals built essentially on the vegetable type of structure.*

All radiates are aquatic, and nearly all marine. They comprise three Classes:

1. ECHINODERMATA or radiates with a tough skin, containing calcareous particles; or with a shell composed of calcareous plates, movable or fixed, and bearing tubercles or spines. Sea-cucumbers, Sea-urchins, Star-fishes, Serpent-stars, and Crinoids are examples.
2. ACALEPHÆ or radiates of a jelly-like consistency; as Jellyfishes.
3. POLYPI or radiates which are flower-like in form, and with the body divided into vertical chambers by vertical plates; as Coral-animals and Sea-anemones.

Some naturalists refer the forms here called Radiata to two sub-kingdoms — Echinodermata and Cœlenterata. (See foot-note, p. 284.)

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* The above is true as a general statement. But it must be added here that most radiates exhibit some indications of an anterior and a posterior end, and more or less of bilateral symmetry.

It may be added here that Von Baer has shown that in each of the four great branches of the Animal Kingdom there is a special mode of development in the egg. In the Vertebrates the germ divides into two folds—one turning upward, and the other downward. In the Articulates, the germ lies with its back on the yolk. In the Mollusks the germ lies upon the yolk and absorbs it into the under surface of the body. And in the Radiates the germ occupies the whole periphery of the sphere.

SECTION II.

THE CLASS OF ECHINODERMATA OR ECHINODERMS.

SUB-SECTION I.

THE ECHINODERMATA CONSIDERED AS A CLASS.

THE Echinodermata are radiate animals which have a tough skin containing particles of carbonate of lime, or a shell composed of calcareous pieces, which are movable, or fixed together, and covered with tubercles or spines.

The parts of their structure radiate from the mouth or oral opening, and meet in the opposite pole or ab-oral region; and in general there are, along certain of the rays, regular rows of tubular suckers used in locomotion.

The name Echinodermata comes from the Greek *echinos*, a hedgehog, and *derma*, skin, and is given to these animals because many of them are covered with spines, as stated above, thus reminding us of the hedgehog (Fig. 135) of the fields.

In the Radiates there is generally a reigning number—a number to which the parts conform. In the Echinoderms this number is *five;* that is, the parts are five, or some multiple of five.

The internal organs are quite well defined. In the Holothurioids and Sea-urchins, the alimentary canal, forming one or two turns, extends through the whole length of the animal. In the Star-fishes the digestive cavity is a sac with branching appendages, and with only one opening.

The circulatory apparatus is well developed, the blood being distributed in real blood-vessels.

Respiration is performed by means of branchiæ, by organs performing other functions, and by water passing into the cavity of the body, and thus aerating the blood through the capillary vessels of the viscera.

The muscular system is well developed. The nervous system consists of a ring around the commencement of the œsophagus, which sends off branches along the rays.

Echinoderms increase by means of eggs, are marine, and are abundant on almost every coast; and the remains of extinct species fill the rocks in many regions.

The Echinodermata are divided into five Orders:

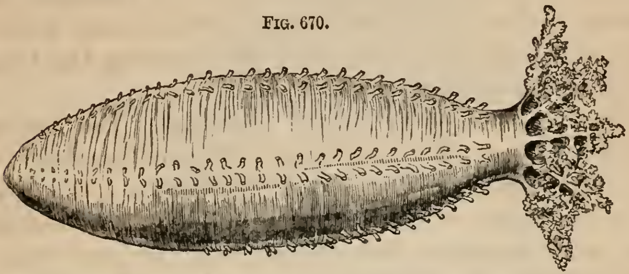
1. HOLOTHURIOIDEA or those with a long and more or less cylindrical body covered with a tough skin containing calcareous particles; as Sea-Cucumbers, etc.
2. ECHINOIDEA or Echinoderms with a hard shell covered with spines; as Sea-Urchins.
3. ASTERIOIDEA or Echinoderms which are star-shaped, and covered with a skin filled with movable plates, and bearing tubercles instead of spines; as Star-fishes.
4. OPHIURIOIDEA or star-shaped Echinoderms, whose long, slender, brittle arms start off abruptly from the relatively small disk, and taper like a snake's tail; as Serpent-stars.
5. CRINOIDEA or Echinoderms which, either in their larval or adult form, are provided with a stem; as Crinoids, both living and fossil.

SUB-SECTION II.

THE ORDER OF HOLOTHURIOIDEA OR HOLOTHURIANS.

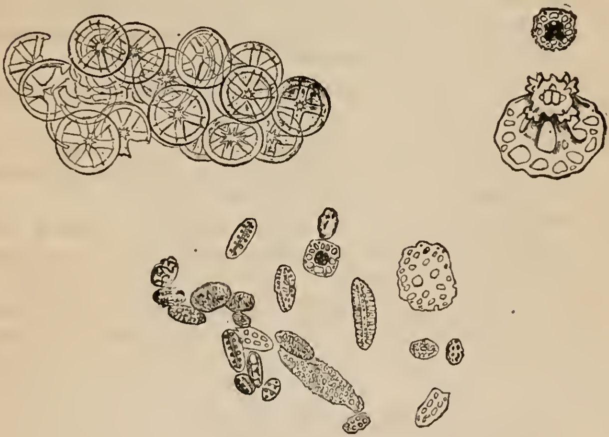
THE Holothurioids are echinoderms which have the body long, cylindrical, somewhat worm-like in general appearance, with a row of appendages around the oral opening, and without a calcareous shell, but with a tough, leathery envelope, capable of great dilation and contraction, and generally containing more or less of calcareous particles. The different species vary from an inch to a foot in length.

FIG. 670.



Holothurian, or "Sea-Cucumber," *Pentacta frondosa*, North Atlantic.

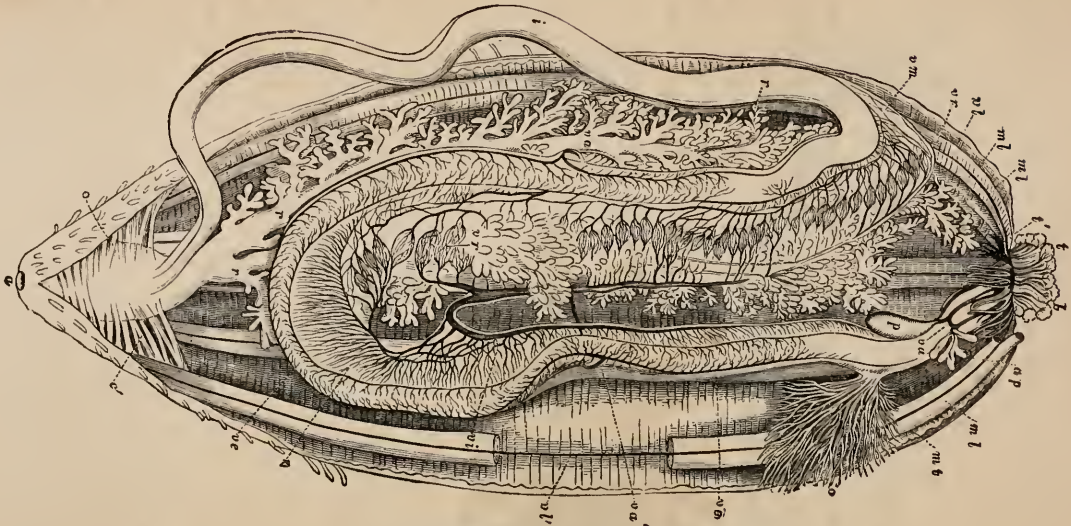
FIG. 671.



Plates from the skin of Holothurians,—magnified.

Pentacta frondosa (Fig. 670) is very abundant at Grand Menan, on the coast of Maine. It resembles the kind called Trepang, which the Chinese use for food.

Fig. 672.



Internal structure of a Holothurian.

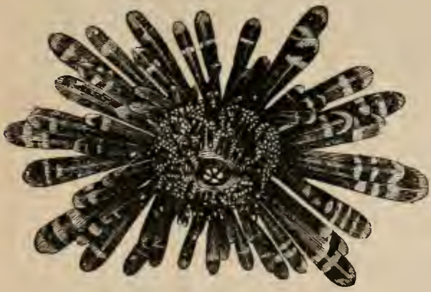
a, vent ; *b*, mouth : *c*, cloaca surrounded by dilators *c* ; *i*, intestine; *m*, mesentary; *ml*, *ml*, longitudinal muscles ; *mt*, transverse muscles ; *o*, ovary ; *ap*, cæcal appendages ; *p*, heart? ; *r*, *r*, respiratory apparatus ; *t*, oral tentacles ; *t'*, cæcal reservoirs ; *va*, annular vessels surrounding the mouth; *ve*, external intestinal vessel, and *va'*, branch of the same; *vi*, internal intestinal vessel; *vl*, longitudinal tegumentary vessels giving off branches *vl'*; *vm*, mesenteric vessels; *vr*, respiratory system of vessels.

SUB-SECTION III.

THE ORDER OF ECHINOIDS OR SEA-URCHINS.

THE Echinoids are echinoderms which have a more or less spherical or discoidal shell composed of definitely formed and symmetrically arranged plates, which are covered and firmly bound together by a skin, and which bear tubercles which are crowned with spines.

FIG. 673.



Sea-urchin, *Echinus mammillatus.*

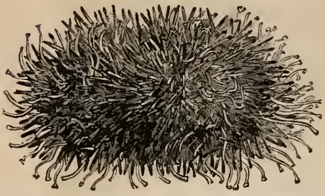
The plates are so arranged as to divide the shell into more or less distinctly marked zones, radiating from the oral opening.

In every alternate zone the plates are perforated for the passage of the locomotive suckers or ambulacra, and are called *ambulacral* plates; and the plates of the other zones are not perforated, and are called *interambulacral* plates.

By means of the suckers, which can be extended much beyond the spines, these animals can cling firmly to other bodies, and thus move about over the rocks, and even up and down their smooth sides, as well as on level surfaces.

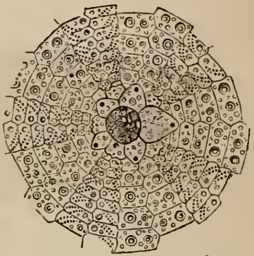
At the termination of each of the five belts or zones of ambulacral plates there is a little triangular plate with a minute opening which marks the place of the eye. Alternating with the eye-plates are five larger plates, each perforated with a larger hole, through which the eggs are laid. One of these plates is larger than the others, and is filled with very minute holes, and is called by naturalists the *madreporic body*. It is believed to serve as a filter to the water which passes through it into the body of the animal.

Fig. 674.



Sea-Urchin, *Toxopneustes drobachiensis*, Ag. Both coasts of the United States, at the North.

Fig. 675.



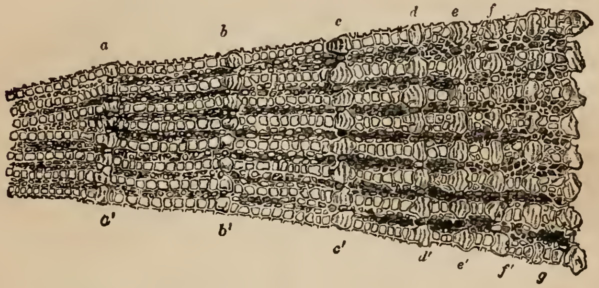
Top view of Sea-Urchin, spines removed. Shows ambulacral and interambulacral plates.

The mouth is in the under side, and is armed with five strong pointed and polished teeth, which form the outer part of a remarkable dental apparatus, which is called *Aristotle's lantern.*

In a Sea-urchin of ordinary size there are five or six hundred plates, all fitting together in the most perfect manner, and bearing more than four thousand spines; and the suckers number about two thousand!

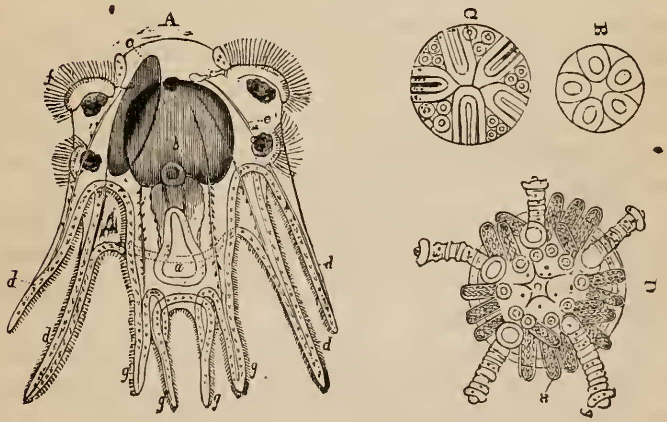
Besides the spines and the suckers, there are scattered over the body and around the mouth of the Sea-urchin a great number of curious little organs called *Pedicillariæ*. They look like a stem ending in a knob; but the knob is composed of three pieces or blades, which open and shut tightly, thus forming a sort of pincers. The uses of

FIG. 676.



Small portion of a cross section of a spine of a Sea-urchin.

FIG. 677.



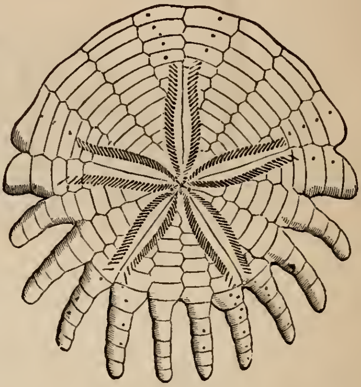
Embryonic development of a Sea-urchin.

A, Pluteus larva; *a*, mouth; *b*, stomach; *c*, echinoid disk; *d*, arms of the pluteus larva; *g*, ciliated processes of the proboscis; B C D, disk in progressive stages of development.

these organs are not fully understood; but one of their uses is to aid in keeping the spines clean.

The Echinoids represented by Figs. 673–675 have the mouth below and the vent above, and both central; and they have the ambulacra in five pairs continuous from the mouth to the vent, and so they are called the Regular Echinoids.

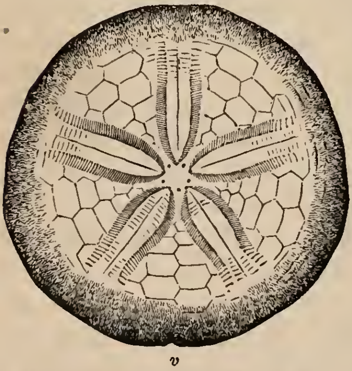
FIG. 678.



Finger-Urchin, *Rotula Rumphii*. Cape Palmas.

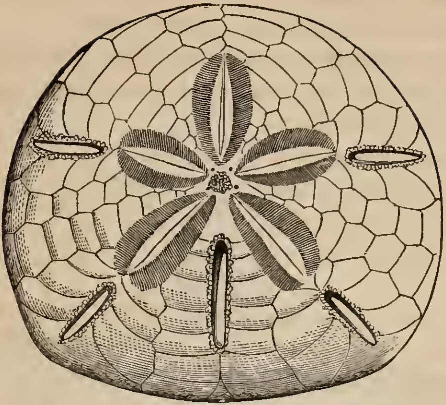
Besides these there are many kinds of Sea-urchins—mostly much flattened, and in many cases elongated in one direction more than in the other—which have the mouth below, and the vent not opposite and central, but sometimes below, and sometimes at one side (Fig. 679), and the ambulacra not continuous; and in many cases the shell is very curiously modified, exhibiting holes, fingers, etc. (Figs. 678, 680), quite different from anything seen in the typical Sea-urchins — therefore they are called Irregular Echinoids.

FIG. 679.



Cake-Urchin, *Echinarachnius parma*, Gray. North-east coast of the United States.

Fig. 680.



Key-hole-Urchin, *Mellita quinquefora*, Agassiz.
Tropical America.

Sub-Section IV.

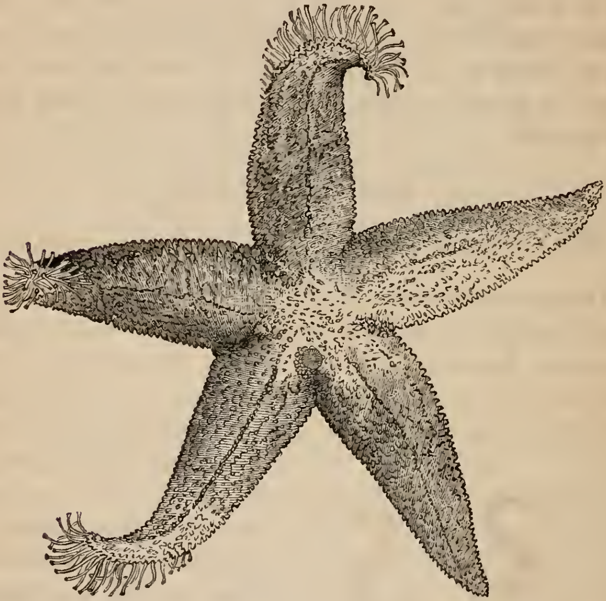
The Order of Asterioidea or Star-Fishes.

The Star-fishes are echinoderms which are more or less star-shaped, the disk or central portion gradually merging into the rays. Beneath each ray there is a large number of locomotive suckers, like those of the sea-urchins already described. The mouth is on the under side in the center, and there is an eye, or eye-spot, at the end of each ray.

By means of the ambulacral tubes, or suckers, Star-fishes move over the rocks and all kinds of surfaces; and they cling to the rocks so firmly that they are removed with difficulty, and will sometimes even allow their ambulacra to be pulled off rather than let go their hold.

Their covering is not solid as in the Sea-urchins, but is composed of movable plates, so that these animals are able to bend themselves in every direction, and thus work their way into holes and fissures in rocks where we would not expect to find them. Star-fishes feed upon mollusks and other marine animals; and when they feed they turn the stomach out of the mouth and over the food to be devoured.

FIG. 681.



Star-fish, *Asteracanthion.*

On the back, near the junction of two of the arms, is the madreporic body, described in speaking of the Sea-urchins. It is a sort of minute sieve, and forms an entrance to a series of internal water-tubes, some of them connecting with the locomotive suckers and supplying them with water. Water is also admitted into the body through minute holes which cover the whole surface of the animal.

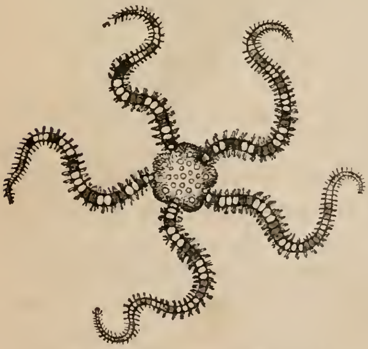
Star-fishes often lose one or more of their arms by being dashed against the rocks by the waves, or the arm is bitten off by a fish. In such cases a new one sprouts out in the place of the old one; and specimens may be found showing such new rays in all stages, from those that have just begun to sprout, to those that have nearly reached their full growth.

SUB-SECTION V.

THE ORDER OF OPHIURIOIDEA OR SERPENT-STARS.

THESE curious echinoderms, which hide under the sea weeds and in the darkest crevices of the rocks of the sea, have long tapering arms which start off abruptly from a comparatively small and a well-defined disk. They thus differ in a marked degree, even in external form, from the true Star-fishes, which have the disk or central portion comparatively large; and gradually merging into the arms.

FIG. 682.

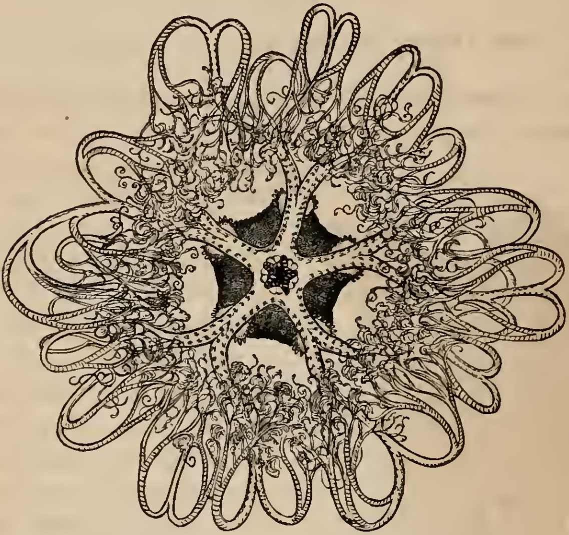


Serpent-Star, *Ophiopholis bellis*, Lyman.

The name of this order is from *ophis*, a snake, and *oura*, a tail; the arms taper like a snake's tail. The Ophiurans are often called "Brittle Stars," because they are exceedingly fragile, breaking at a very slight touch; and they also readily break themselves into pieces, probably by contraction.

The Ophiurans have no teeth, but in place of teeth hard ridges. They have no interambulacral spaces or plates; but a single series of large plates envelop the whole of each arm, meeting in a ridge along the middle of its under surface. They have no true suckers like those of Star-fishes, etc.; but in place of these they have rough or tuberculated organs, which pass out through the numerous holes in the sides of the arms. Their madreporic body is one of the circular plates on the under side of the disk; and the ovarian openings are in each side of the arms, at the base.

FIG. 683.



"Basket-fish," *Astrophyton Agassizii*, Stimpson.

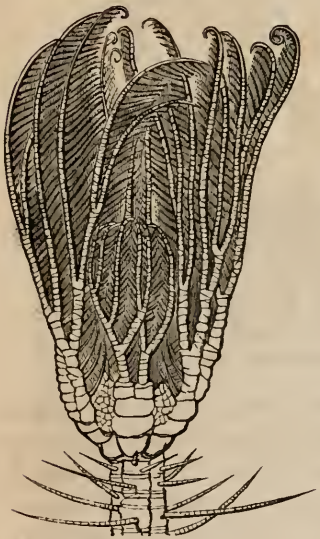
Most of the Ophiurans have the arms simple; but one kind—the Astrophyton—which attains a diameter of ten or twelve inches, has the arms extensively branched, the arms dividing and subdividing until the branches are said to number more than 80,000 !

SUB-SECTION VI.

THE ORDER OF CRINOIDEA OR CRINOIDS.

THE echinoderms of this order are called Crinoids on account of the plant-like or lily-like appearance of many of the species, especially of those found fossil in the rocks. The name Crinoid is from *krinon*, a lily, and *eidos*, like.

FIG. 684.



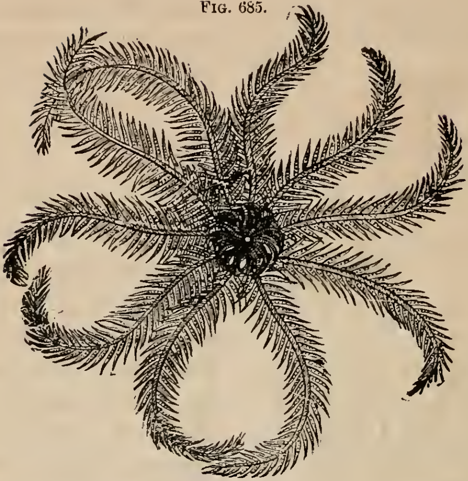
Crinoid, *Pentacrinus caput-medusæ.* West Indies.

In the Crinoids we see a great development of the aboral region as compared with the oral; and the former is generally calyx-like, and composed of immovable plates, and in many cases the whole supported on a long flexible stem composed of many plates of a beautiful structure.

Some kinds of Crinoids, as the Rosy Feather-star or Comatula, have a stem in the young state, but at length drop from the stem and spend the remainder of their life as free crinoids.

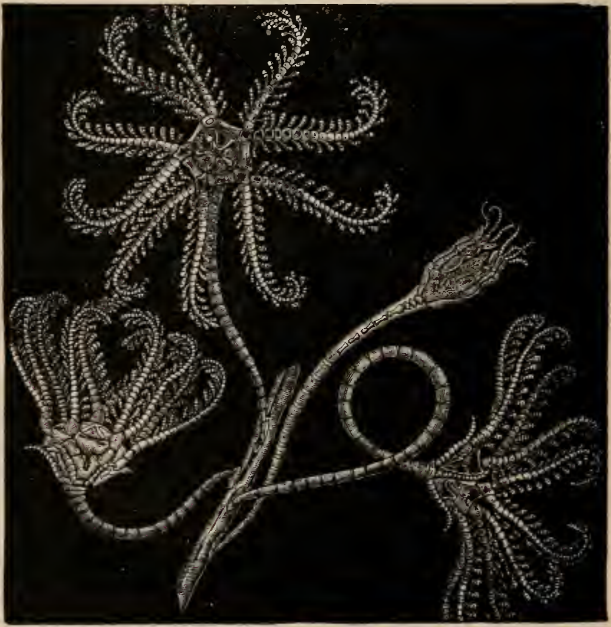
There are but a few living species of Crinoids. But in the rocks, in various parts of the United States and in

FIG. 685.



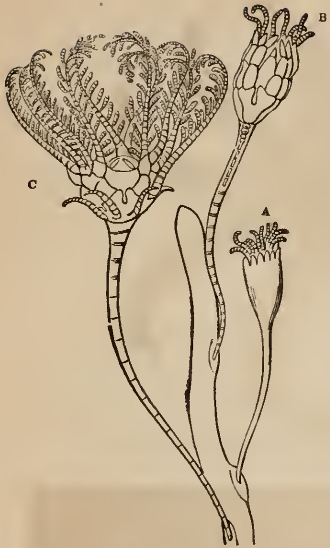
Free Crinoid—Rosy Feather-star, *Comatula rosacea.*—Adult.

FIG. 686.



Crinoid.

FIG. 687.



Early stages of a free Crinoid — Rosy Feather-star, *Comatula rosacea*. A, very early stage; B, farther advanced; C, just ready to drop from the stem and become a free crinoid (FIG. 685). Magnified.

other countries, the stemmed kinds are exceedingly abundant, showing that these animals lived in profusion in the old oceans which ages ago covered a large part of our country and of other countries. And the fossil crinoids, especially, are so various in forms, and so beautiful in patterns and markings, that no words can fitly describe them. The workman in the quarry stops to admire them, and the learned naturalist is fascinated by their beauty, and never grows weary of studying them. They are the "gems" of the geological collection, and their pictures are among the most interesting to be found in the Geological Reports of the States where these fossils abound.

Special students of the Echinoderms are referred to the writings of A. Agassiz "On the Embryology of the Echinoderms,"—and to his work on the the "Revision of the Echini."

SECTION III.

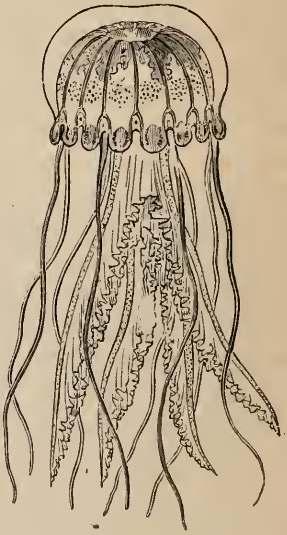
THE CLASS OF ACALEPHÆ OR JELLY-FISHES.

SUB-SECTION I.

THE ACALEPHS CONSIDERED AS A CLASS.

THE Jelly-fishes are among the most wonderful of all the animals of the sea. Their jelly-like bodies, curious forms and structure, their beautiful colors, of claret, rose, and pink, their varied and almost magical movements, as varied and graceful as those of the birds and insects of the air, their phosphorescence by night, causing them to be called the "*Lamps of the Sea*," and their curious changes in passing from the young to the adult state, have interested all intelligent visitors to the sea-side, and have caused these animals to be carefully studied by some of the most eminent of naturalists.

FIG. 688.



Jelly-fish, *Pelagia cyanella*, Ag.

The name Acalephæ (from the Greek *akalephe*, a nettle) is given to these animals because some of them cause a stinging sensation when they touch our flesh; hence they are often called Sea-Nettles. They are also as often called Medusæ.

If we examine the structure of Acalephs, we find a cavity or stomach, hollowed out of the mass of the body, and in most cases this cavity has an opening or mouth; the edges of this opening are turned outwards and prolonged into fringes. And there are tubes which radiate from the center of the body and unite with a tube at the circumference. Jelly-fishes also have long or short tentacles.

The kinds of Jelly-fishes are numerous, and they vary in size from those scarcely visible to those which are one or two yards in diameter, and with tentacles thirty or forty feet long. Alexander and Mrs. E. C. Agassiz ("Sea-side Studies,") mention one which measured about seven feet in diameter, and had tentacles more than a hundred feet in length!

Jelly-fishes feed upon their own kind, and other marine animals, which they secure by means of their tentacles and *lassos*. On the tentacles of Jelly-fishes, and of Polyps, there are numerous microscopic lasso-cells, each containing a long spirally-coiled thread or lasso, which can be instantly darted forth and fastened upon the little shrimp or other animal desired for food.

According to Agassiz the Acalephæ may be divided into three Orders:*

1. CTENOPHORÆ or acalephs with a more or less spherical or melon-shaped form, and with the body made up of eight homologous segments bearing eight rows of locomotive appendages; as *Pleurobrachia*, *Beroë*, *Idyia*, etc.
2. DISCOPHORÆ or jelly-fishes with a more or less hemispherical or disk-shaped form, with fringes or tentacles around the outer margin; as *Aurelia*, *Cyanea*, *Pelagia*, etc.
3. HYDROIDEA or acalephs which are plant-like, or polyp-like in form—some kinds resembling ordinary medusæ; as *Coryne*, or *Sarsia*, *Tubularia*, *Hybocodon*, *Campanularia*, *Sertularia*, *Tiaropsis*, *Physalia*, etc.

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* See the splendid works of Agassiz: "Contributions to the Natural History of the United States," from which all but one of our cuts of the Acalephs are copied.

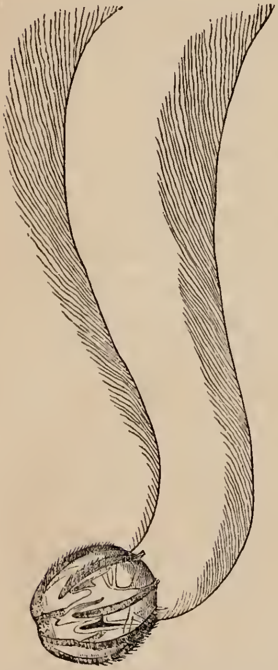
SUB-SECTION II.

THE ORDER OF CTENOPHORÆ OR BEROID MEDUSÆ.

THE Beroid Medusæ are more or less spherical, or melon-shaped, with eight rows of locomotive fringes dividing the surface of the body as the ribs divide the surface of a melon.

Pleurobrachia is one of the most common kinds on the north-east coast of the United States, and in its movements and curious appendages is one of the most wonderful of all the Medusæ. It is transparent, and besides the eight rows of fringes, it has two most extraordinary tentacles; and no form of expansion or contraction, or curve, or spiral, can be conceived of which these tentacles do not assume.

FIG. 689.



Pleurobrachia rhododactyla, Agassiz.

Bolina and *Idyia* are other ctenophoræ common on the north-east coast of the United States. The Rose-colored Idyia is three or four inches long, and shaped somewhat like a melon with one end cut off; and the mouth occupies the whole of the cut-off end, and the digestive cavity, or stomach, occupies a large part of the interior of the animal. In summer it sometimes appears in such swarms as to tinge large patches of the sea with a delicate rosy hue.

SUB-SECTION III.

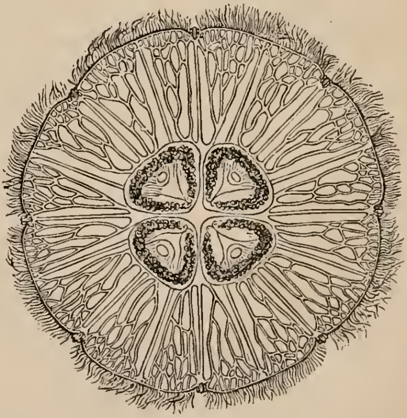
THE ORDER OF DISCOPHORÆ OR MEDUSÆ PROPER.

THE Jelly-fishes which belong to the order of Discophoræ are more or less hemispherical—often considerably flattened and disk-shaped.

The species are very numerous and varied in form, structure, and color. Some kinds are very small, and others are the largest and most magnificent of all the Jelly-fishes, attaining a diameter of several feet, and in some cases having tentacles a hundred feet in length.

One of the common species of this group is the "Sun-fish," *Aurelia flavidula* (Figs. 690–693), of the North Atlantic. It attains a diameter of eight to twelve inches. In the spring it is about a quarter of an inch in diameter, and in pleasant days it moves in large swarms near the surface of the water.

FIG. 690.



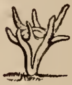
"Sun-fish," *Aurelia flavidula*, Peron and LeSueur. Offspring of Figs. 691-3.

About the middle of summer the Jelly-fishes of this species become full grown. Towards the close of summer they lay their eggs; and in the autumn they perish.

At length the eggs hatch, and the little *planulæ*, as the newly-hatched Jelly-fishes are called, swim about in the water by means of little appendages called *vibratile cilia*.

Soon each becomes attached to a rock, shell, or seaweed, and is then called *Scyphistoma* (Fig. 691).

FIG. 691.

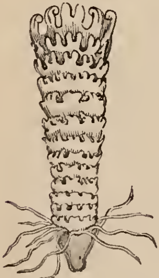


Scyphistoma of *A. flavidula*, Per. and LeS. Magnified about seven diameters.

Then the body begins to divide by horizontal constrictions, and soon appears as in Figs. 692, 693, and is then called *Strobila*.

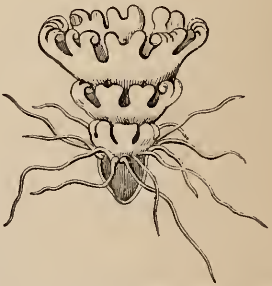
At length the segments become more and more separated, and the uppermost one drops off; then the next one; then the next, and so on, till each in turn has separated from the one below itself.

FIG. 692.



Strobila of *A. flavidula*, Per. and LeS. Magnified about seven diameters.

FIG. 693.



Strobila of *A. flavidula*, Per. and LeS. Magnified fifteen diameters.

Each disk, as it separates, turns over and floats away, and is known as *Ephyra*.

Soon each Ephyra assumes the form of a perfect Jellyfish, as shown in Fig. 690.

It is thus seen that we have here another illustration of "parthenogenesis," or "alternations of generations" (see page 329). The egg hatches into a *Planula*, which soon becomes a *Scyphistoma;* the scyphistoma becomes a *Strobila;* and the strobila breaks up into *Ephyræ*, which soon become perfectly formed into Jelly-fishes which lay the eggs.

SUB-SECTION IV.

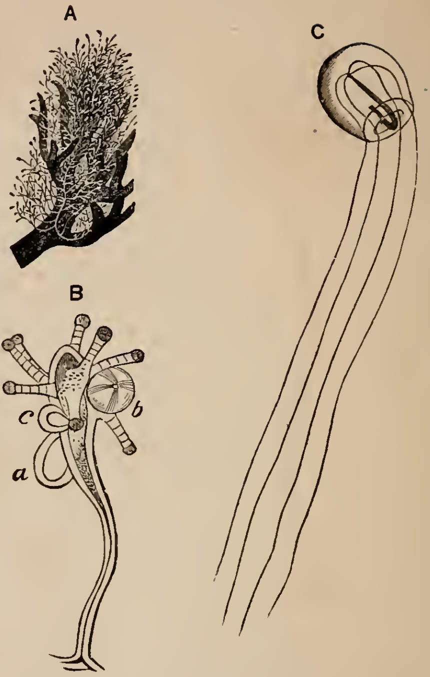
THE ORDER OF HYDROIDEA OR HYDROIDS.

THE Hydroids are Jelly-fishes which are even more wonderful in their mode of development than those already described. Occurring as they do in many cases, in their early stages of existence, as mere discolored patches on sea-weeds, stones, or shells, or in appearance like little tufts of moss, or miniature shrubs, the untrained eye might well mistake the fact that they are animals.

But naturalists have shown that these plant-like forms produce medusæ buds, which expand into genuine medusæ or jelly-fishes. Fig. 694 shows a little cluster of Hydroids attached to sea-weed, and Fig. 694B shows a single individual of the same, very much magnified, with two of the buds much enlarged, and a third quite prominent. At length each bud becomes detached, and floats away as a free jelly-fish, like Fig. 694C, and is then known as Coryne; or, as it was formerly called, Sarsia—the latter name from Sars, a Norwegian naturalist, who was one of the earliest investigators of these curious kinds of Jelly-fishes.

Coryne is almost as delicate and as transparent as a dew-drop, yet it performs varied and rapid movements, contracts and expands its tentacles, catches and devours other small jellyfishes, and other small marine animals and thus gives abundant evidence that it is a real member of the animal kingdom. The jellyfishes of this sort are abundant in the spring. In the middle of summer they lay their eggs, and perish. But the eggs do not hatch into medusæ like the parent; but each egg hatches a little hydroid which is first free, then afterwards becomes attached to a shell, sea-weed, or stone, and from this little hydroid others branch till a little community of hydroids has grown up, as in Fig. 694A.

Fig. 694.

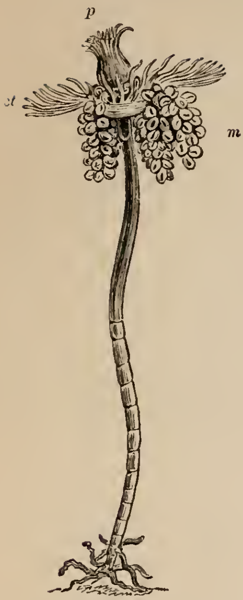


Hydroid Jelly-fish, *Coryne* (*Sarsia*) *mirabilis*, Agassiz. A, a cluster of hydroids growing on sea-weed; B, a single individual enlarged—*a* and *b* just ready to drop off and become free Jelly-fishes C.

And here again we have an illustration of Parthenogenesis (page 329).

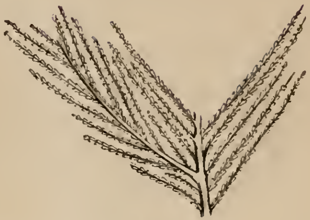
In some kinds of Hydroids, as Tubularia (Fig. 695), there is a wreath of coronal tentacles, and a projecting part called a proboscis, and the medusæ grow in clusters from just above the coronal tentacles.

Fig. 695.



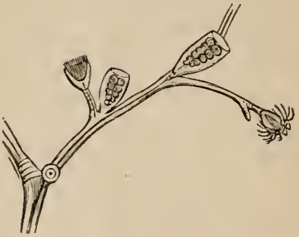
Tubularia.
m, medusæ; *ct*, coronal tentacle; *p*, proboscis.

Fig. 696.



Sertularia.

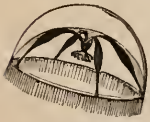
Fig. 697.



Campanularia.—The hydro-medusæ in the bell-shaped cups drop out and become free medusæ similar to Fig. 698.

In the Sertularians (Fig. 696) and Campanularians, the hydroid has a stem which is covered by a horny sheath, which is formed into few or many bells or cups. In a fertile cup there are hydro-medusæ, which at length drop out and become free medusæ similar to Tiaropsis (Fig. 698).

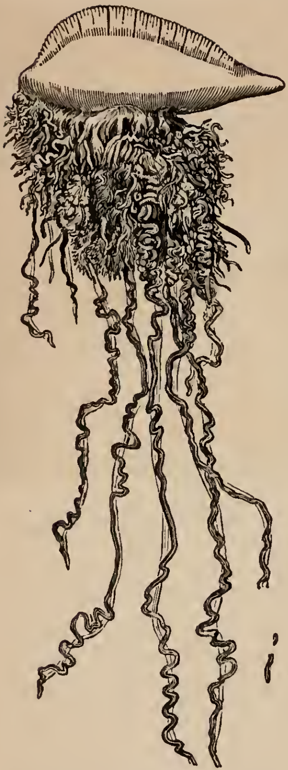
Fig. 698.



Tiaropsis.

In the Siphonophoræ the hydroid acalephs exist as free communities, each community being made up of individnals of different kinds, yet all so combined as to give the appearance of one animal. The "Portuguese Man-of-War," of the Gulf of Mexico, is of this sort. It consists of an elegantly crested air-sac, floating upon the water, and giving off numerous long and varied appendages. According to Agassiz, these are the different members of the community, and fulfill different offices; some of them eating for the whole, others producing medusa buds, and others being the locomotive or swimming members, and having tentacles that stretch out behind the floating community to the length of twenty or thirty feet.

FIG. 699.

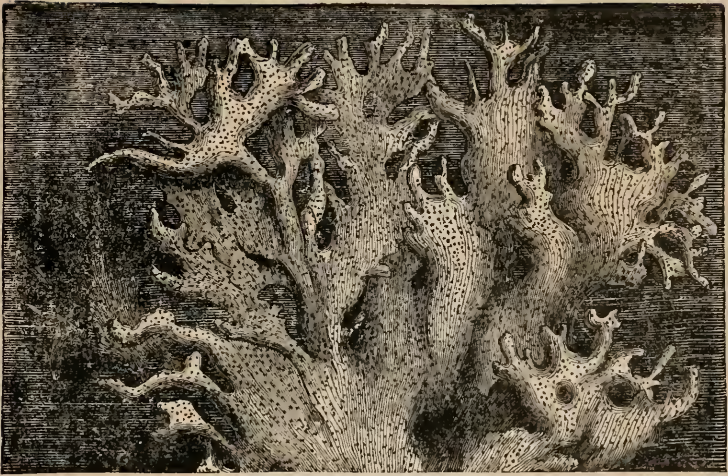


Portuguese Man-of-War, *Physalia arethusa.*

According to Agassiz, there are some kinds of Acalephs which produce coral similar to that formed by Polyps, described in the following pages. *Millepora* is a genus of coral of this sort (Fig. 700.)

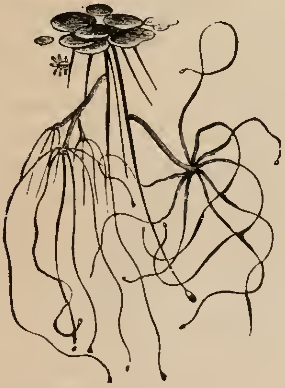
To the Hydroidea belong also the so-called "fresh-water polyps" (*Hydra*). These are common in fresh-water ponds and streams, and are found attached to the stems and leaves of aquatic plants. They are merely a living tube-like sack, with the margin prolonged into eight tentacles. They have become celebrated on account of the

Fig. 700.



Millepore Coral, *Millepora alcicornis.*

Fig. 701.



Fresh-water Polyp, *Hydra,* — two adult specimens attached to aquatic plants; the one on the left with two younger specimens branching from its side. Enlarged.

wonderful experiments made with them by Trembley, more than a hundred years ago, and essentially repeated by many others in later times.

Trembley found that whether cut in two, or into many rings, or into longitudinal strips, each part became a perfect animal. He found that if he split them from the mouth, part of the way down the body, each section became a perfect animal, and that a many-headed hydra was thus produced. And that when he turned them inside out, and compelled them so to remain, they experienced no harm, but after a few days devoured their food as if nothing had happened!

SECTION IV.

THE CLASS OF POLYPI OR POLYPS.

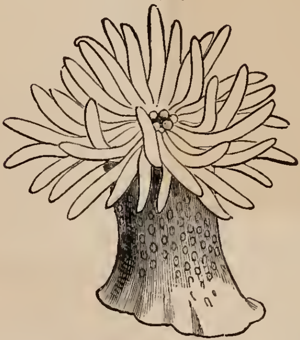
SUB-SECTION I.

THE POLYPI CONSIDERED AS A CLASS.

OF all the animals of the ocean, probably none have a more interesting history than the Polyps—the "Flowers of the Sea;" and they and their products have long engaged the attention of the most cultivated minds.

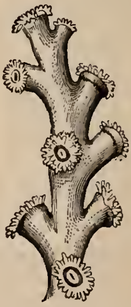
Theophrastus, Pliny, Cuvier, Milne-Edwards, Darwin, Dana, and Agassiz, are some of the illustrious names which we find in connection with the written history of these flower-like forms which constitute the lowest class of the Radiata.

FIG. 702.



A Polyp—Sea-anemone, *Bunodes stella*, Verrill.

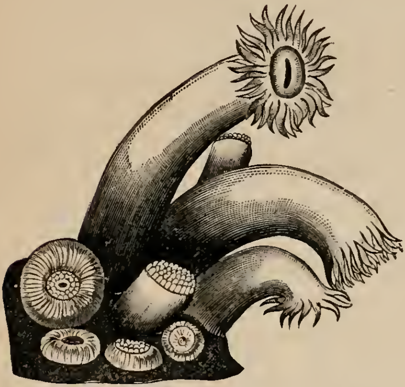
FIG. 703.



Coral Polyps, *Cœnopsammia nigrescens*, Milne-Edwards.

Polyps are marine radiates which have a sack-like or tubular body, with a circular top or disk, in the center of which is an opening called the mouth; and surrounding the mouth are one or more rows of hollow feelers or tentacles.

FIG. 704.

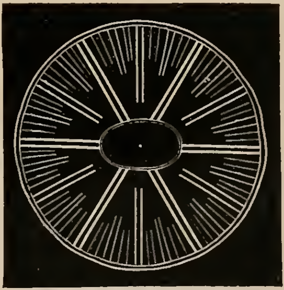


Cluster of Coral-Polyps, *Asteroides calycularis*, M. Edwards—in various stages of expansion.

The mouth opens directly into an inner sack, which is the stomach, and this stomach opens at the bottom into the main cavity of the body.

The main cavity of the body is divided by radiating septa or partitions, which run from the bottom to the top, and from the outer wall to the stomach. These radiating partitions are in pairs, and the number of

FIG. 705.*



Cross section of a Polyp, showing the Septa.

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* Figs. 668, 700, 705, 706, 707, 713, 721, and 730, are from Dana's splendid "Coral and Coral Islands."

pairs is some multiple of six—*six* pairs in the first series; *six* in the second; *twelve* in the third; *twenty-four* in the fourth; *forty-eight* in the fifth, etc. And the compartment between the two septa of each pair opens into the hollow tentacle above.

Professor Verrill has shown that the tentacular compartments indicate the ambulacral segments of the Polyp.

The food of polyps consists of small marine animals, which are secured by means of the tentacles, and the curious and wonderful organs called lassos.

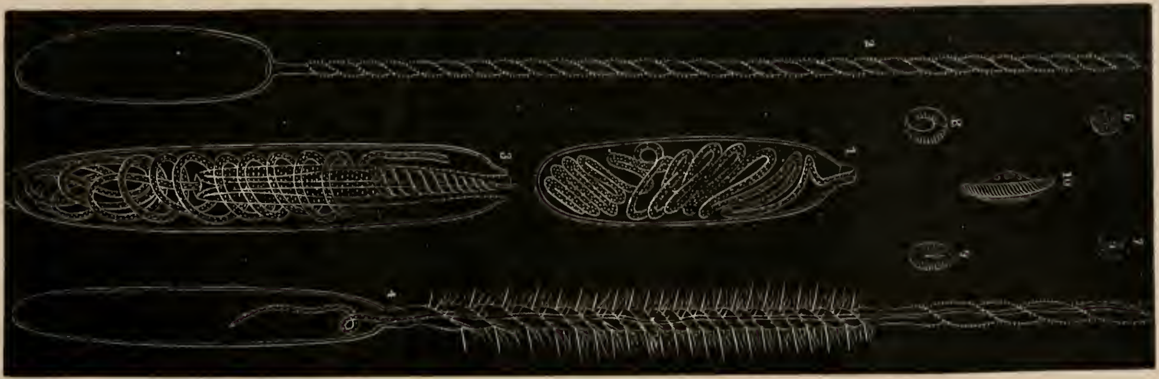
On the tentacles, and about the mouth, and on the walls of the stomach, and in the white cords often seen hanging from the folds of the radiating septa, are vast numbers of cnidæ or *lasso-cells*, each one being less than $\frac{1}{200}$ of an inch in length. In each cell there is a long, slender coiled-up thread or lasso; and these threads can be darted forth with almost lightning-like rapidity, and the little animal upon which they strike, and into whose tissues they penetrate and carry poison, as is believed, is instantly paralyzed, and is thus readily secured by the hungry polyp for food. The lasso in some cases is twenty to forty times as long as the cell.

After digesting the soft parts of the animals which they capture, they eject the shell or other hard parts through the mouth. And it may be stated here that the substance of some kinds of polyps, as the Actiniæ or Sea-anemones, is so extensible that they can swallow and eject shells of almost as great diameter as themselves. The expansion and contraction is accomplished by means of two sets of muscles, one set circular, and another longitudinal.

After being digested the food passes into the main cavity of the body, and thence into the chambers and tentacles, thus nourishing every part.

The Polyps have no proper nervous system. The sense of touch is distributed throughout the whole animal; but as to sight, it is quite remarkable that some kinds of Sea-

FIG. 706.



Cnidæ, or Lasso-cells, some with the lasso coiled within, and others with the lasso extended. Owing to the shortness of the page, only a part of the length can be shown.

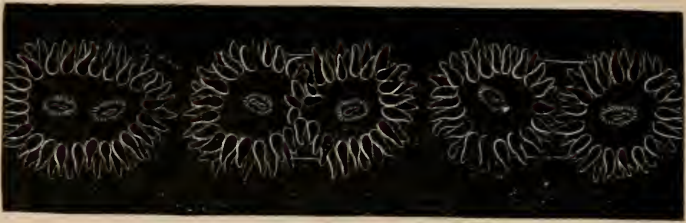
1. Lasso-cells of an Actinia, with the lasso coiled within—its actual length $\frac{1}{360}$ of an inch. 2. The same as 1, with the lasso extended. 3 and 4 are alike—the former with the lasso coiled within, and the latter with the lasso extended. 6, 7, 8, 9, 10, a lasso-cell in different stages of development.

anemones or Actiniæ have a row of eyes just outside of the tentacles; and, according to Dana, these eyes have crystalline lenses and an optic nerve. It is not probable, however, that these eyes enable the animal to see objects as do those of higher animals.

Most kinds of polyps are attached to the rocks, shells, or other bodies beneath the waves. Some live singly; others in small clusters; and others in communities whose numbers are almost beyond calculation.

Polyps increase by means of eggs; by budding and branching in a manner much like that of trees and shrubs; and by division of one animal into two or more. Thus the largest communities arise from a single animal.

FIG. 707.



Spontaneous fission or division in Polyps—one polyp becoming two.

The eggs are formed on the radiating partitions, and pass out through the mouth into the water.

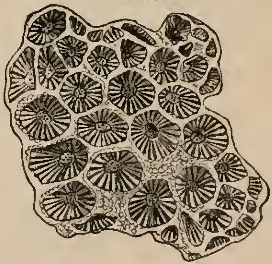
When first hatched the young are not like the parent, but are little oval bodies which move freely about by means of fringe-like appendages called *vibratile cilia.* At length each of these little bodies becomes attached to a rock, or shell, or sea-weed, and soon assumes the form of the parent. If it be a kind which buds, there soon grow from its sides or base others like itself; and from these, in turn, bud other polyps of the same kind; and thus the community goes on growing till it has reached its limits of increase. If it be a kind which increases by division, it widens as it grows upward, and soon there are two mouths instead of one; and at length the polyp is divided into two, so that there are two mouths, and two circular disks surrounded by tentacles, instead of one as before the division; and the polyps thus formed divide in the same way, and this process is continued till from a single polyp there is formed a large and beautiful cluster.

Polyps readily reproduce lost parts; and even if cut in pieces, each fragment, in some cases, will become a perfect animal.

Polyps vary in size from extreme minuteness to those that are more than a foot in diameter. Some kinds, as the Sea-anemones (Fig. 702), are wholly soft; others secrete a more or less solid framework, called *coral* or *corallum.*

Some people suppose that coral is built by an insect, as the bee builds comb, or the wasp its nest; and the industry of this supposed insect is often spoken of. But it is not proper to give the name insect to the Coral-polyps, for they are in no way related to insects, either in appearance, structure, or habits. Coral is not something which is built, but something which *grows. It is the skeleton, or many united skeletons, of polyps;* and these animals exhibit no industry in forming it, any more than do other animals in forming their own bones. Coral is not a house in which the animal lives; on the contrary, the coral is wholly inside of the animals, and it is only

FIG. 708.



Coral, *Asteroides calycularis,* Milne-Edwards.—The Coral of Fig. 704.

when the polyps die, wither, and disappear that we see the solid coral itself.

Polyps grow in various and most wonderful and beautiful forms, imitating almost all kinds of vegetation, lichens, fungi, mosses, ferns, herbs, shrubs, and trees. A hundred years ago, or more, they were thought to be plants; and even Linnæus regarded them as plant-animals, that is, partaking of the character of both plants and animals; but naturalists now regard them as true animals, although they are often called Zoöphytes, a word which means Animal-plants.

The colors of these wonderful animals of the sea are as beautiful and almost as varied as their forms; and some of the polyp communities equal, in splendor of colors, the most beautiful flower-gardens of the land. Even beds of daisies, pinks, and asters have their rivals beneath the waves of the sea.

According to Professor Verrill, the Polyps may be divided into three groups or Orders, thus: *

1. ALCYONARIA or polyps with eight long fringed tentacles around a narrow disk; as "Sea-Pens," Gorgonias or "Sea-fans," Red Coral, Organ-pipe Coral, etc.
2. ACTINARIA or polyps with very numerous tentacles, and in most cases with a perfectly soft body; as Sea-anemones.

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* In Professor Dana's splendid book, "Corals and Coral Islands," the Polyps are grouped thus:

1. ACTINOID POLYPS or the Sea-anemones and the Coral-producing polyps related to the Sea-anemones in their tentacles and in their interior structure. The septa and tentacles are in multiples of six.
2. CYATHOPHYLLOID POLYPS or those like the Actinoids in their tentacles and interior structure, except that the number of tentacles and interior septa is a multiple of *four*. They were the earliest of polyps, and the most abundant of all in the Paleozoic ages.
3. ALCYONOID POLYPS or those having eight fringed tentacles; as the Gorgonias and Alcyonia.

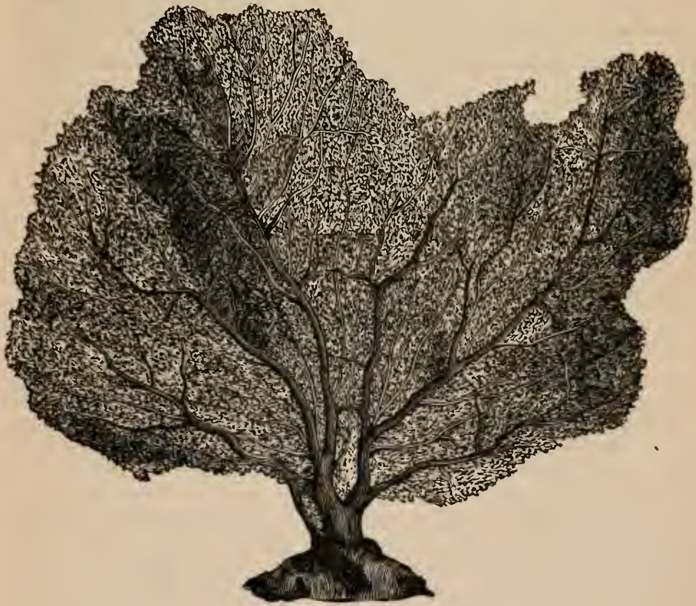
3. MADREPORARIA or coral-producing polyps with a definite number of tentacles—in most cases in multiples of six (apparently only four in the Cyathophylloid corals, all of which are fossil); as Madrepores, Porites, Astræas, Mæandrinas, etc.

SUB-SECTION II.

THE ORDER OF ALCYONARIA OR SEA-PENS, SEA-FANS ETC.

THE Alcyonarians are polyps which have eight long fringed tentacles around a narrow disk, and which form communities by budding. The "Sea-pens" and Renillas

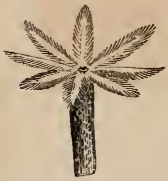
FIG. 709.



Sea-fan, *Gorgonia flabellum.*

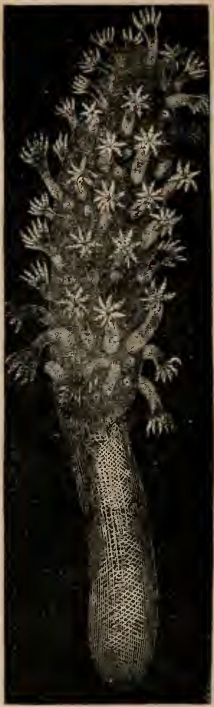
are communities arranged on a more or less expanded disk which has a sort of stem by means of which the community moves about or fixes itself in the sand. These

FIG. 710.



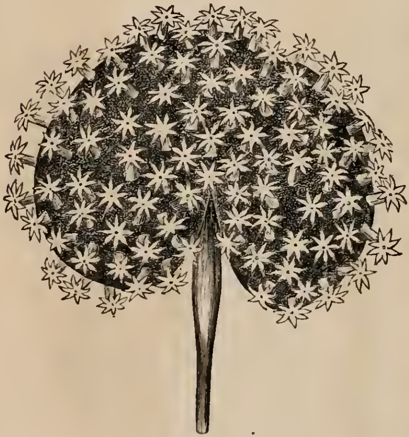
R. Danæ, Verrill.—Single polyp enlarged.

FIG. 711.



Sea-pen, *Veretillum*.

FIG. 712.

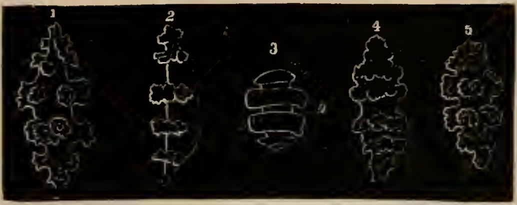


Renilla Danæ, Verrill.

communities are from two to ten inches in length, according to the kinds. All belong to the warm regions.

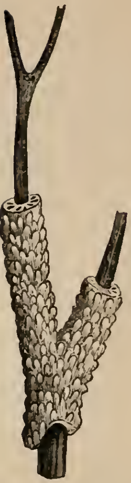
The Gorgonias and their allies—the Gorgonacea of authors—are much branched, and many of them are much

FIG. 713.



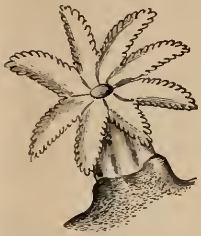
Spicules of Gorgoniæ.—Magnified.

FIG. 714.



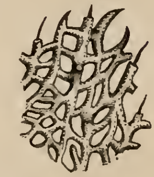
Verrucella gemmacea, Val.

FIG. 715.



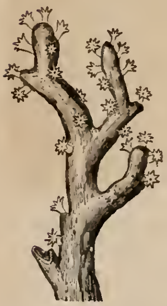
Red coral, *C. rubrum*, Lamarck. Single polyp enlarged.

FIG. 716.



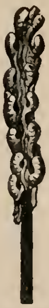
"Fan-coral," *Rhipidogorgia flabellum*, Val. Portion of a large frond.

FIG. 717.



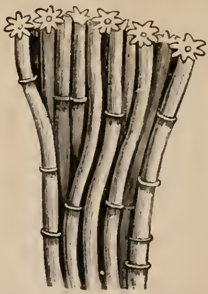
Red Coral, *Corallium rubrum*, Lamarck.

FIG. 718.



Primnoa myura, M.-Edwards.

FIG. 719.



Organ-pipe Coral, *Tubipora syringa*, Dana.

like beautiful flowering shrubs. All secrete a solid central axis, which is either horn-like, or calcareous.

The stems and branches of the Gorgonacea are covered with a layer of united polyps, whose tissues are more or less filled with calcareous particles called spicules (Fig. 713); and it is to these spicules that the Gorgonias owe their various and beautiful colors.

Spicules occur in the other alcyonarians, and they are very important guides in classification.

The Sea-fans are Gorgonias which are broadly fan-shaped, branching in one plane, the branchlets coalescing so as to form a net-work (Figs. 709, 716).

The shrub-like precious coral of the Mediterranean—*Corallium rubrum*, or Red Coral (Figs. 715, 717)—is allied to the Gorgonians. It has a solid calcareous axis of a beautiful crimson or rose color.

Another type of alcyonarians is seen in the Alcyonacea, which occur in the form of arborescent clusters which are more or less fleshy or coriaceous in their texture, but filled with calcareous spicules; or, as in one family—the Organ-pipe coral family,—they form beautiful red calcareous tubes (Fig. 719).

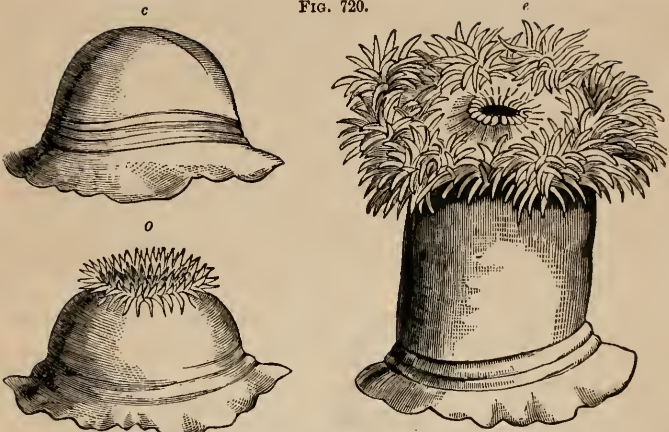
SUB-SECTION III.

THE ORDER OF ACTINARIA OR SEA-ANEMONES.

THE Sea-anemones and their immediate allies have the abactinal region largely developed, and the tentacles conical, or cylindrical.

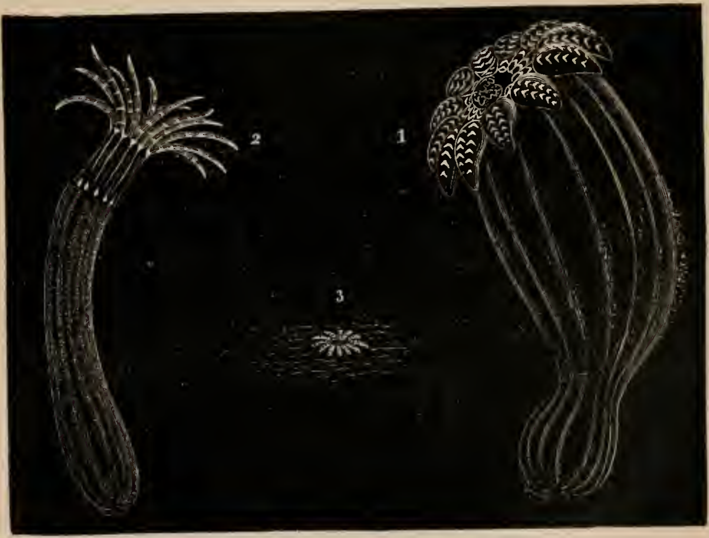
The Sea-anemones or Actinia group have from ten to hundreds of tentacles, and the mouth furnished with folds

FIG. 720.



Actinia or Sea-Anemone, *Metridium marginatum*, Milne-Edwards.—*c*, closed; *o*, opening; *e*, expanded.

FIG. 721.



Actiniæ or Sea-Anemones which live in the sand and are often unattached.
1. *Peachia hastata*, Gosse.—2. *Edwardsia callimorpha*, G.—3. *Halocampa chrysanthellum*, G.—the last mostly buried in the sand.

or lobes. They are free, and effect locomotion by sliding along by means of their fleshy "foot." Most kinds are simple. And nearly all are soft throughout; a few secrete from the base a horn-like substance.

Other actinarians, as the Antipathus group, are compound communities, and appear in the form of delicate shrubs and twigs, attaining a height of three feet in some cases. They secrete a horny axis, which is covered by the united polyps, which have tentacles similar to a Sea-anemone.

Still other actinarians, as the Zoanthids, live in compound communities in most cases, but, like the Sea-anemones, secrete no coral. They are unlike the latter in being incapable of locomotion. The polyps have simple short tentacles on the margin of the disk.

SUB-SECTION IV.

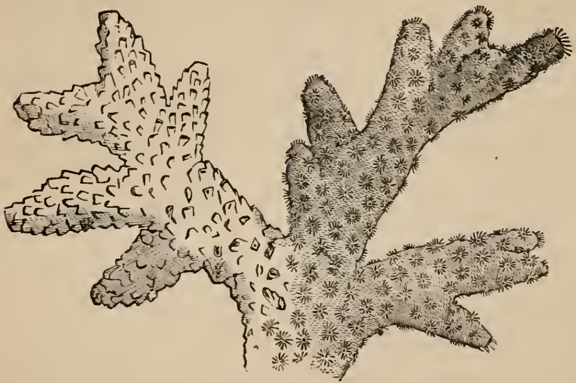
THE ORDER OF MADREPORARIA OR MADREPORES, ASTRÆANS, ETC.

THE polyps of this group are simple or compound, often excessively branching, and they form coral in their walls or outer parts, in their radiating partitions, and often at their base. The forms which the communities assume are very beautiful and exceedingly various, and are among the most beautiful objects in zoölogical cabinets.

The great group of Madreporacea contains polyps which have a definite number of tentacles, twelve or more. Those called Porites (Fig. 723), have the cells shallow, and not more than one-twelfth of an inch in diameter, and the coral in some cases branching, in others massive, and always very solid. Massive specimens of Porites are sometimes fifteen feet in diameter. In the true Madrepores (Fig. 722), the cells of the coral are deep, and these corals spread and branch into the most beautiful and varied forms, and the polyp at the end of a branch is always larger than the others.

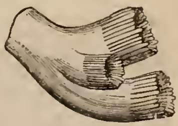
In the great group of the Astræacea the tentacles occur

FIG. 722.



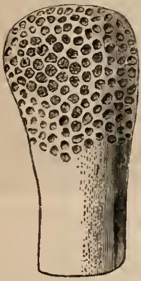
Madrepore, *Madrepora aspera*, Dana. Right-hand branches alive.

FIG. 725.



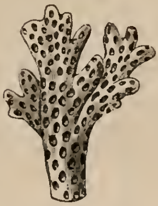
Cladocora flexuosa, Ehr.

FIG. 723.



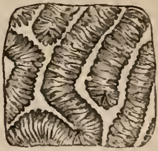
Porites flexuosa, Dana.

FIG. 724.



Pocillopora cæspitosa, Dana.

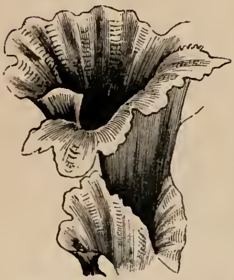
FIG. 726.



Mæandrina gracilis, Dana. Small piece of a large mass.

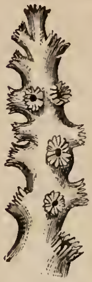
in multiples of six. Those of this group which are called Mæandrinas, have the surface covered with winding trenches (Fig. 726), on each side of which there is a row of tentacles. The form of the Mæandrinas is generally hemispherical, and some of these masses are twelve feet in diameter. The true Astræans, or Star Corals (Fig. 729), have the cells in the form of concave pits, and the com-

FIG. 727.



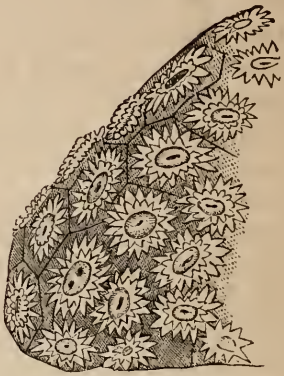
Merulina speciosa, Dana.

FIG. 728.



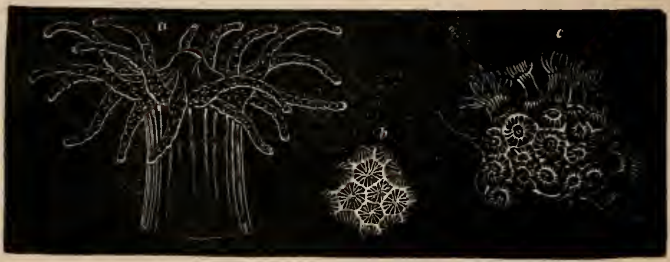
Oculina horrescens. Dana.

FIG. 729.



Astræa pallida, Dana. Portion of large dome, alive.

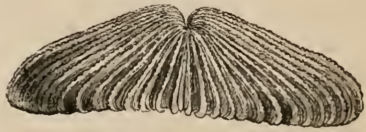
FIG. 730.



Dana's Astrangia, *Astrangia Danæ*, Agassiz.

mon forms of this coral are hemispherical or dome-shaped masses, some of which are twenty feet in diameter; and the polyps themselves are often an inch in diameter. Most of them, however, are very much smaller. One beautiful little Astræan (Dana's Astrangia) has its home in Long Island Sound, where it occurs in little clusters upon the stones and shells. In the Oculinas, the coral when young spreads so as to form a broad base; later beautiful tufts and tree-like branches arise from this base. In one of the groups of the Madreporaria the corals are broad and flat, resembling the fungi of the vegetable kingdom; hence they are called Fungoid Corals. The polyps which secrete this coral have short lobed tentacles in multiples of six. The broad flat specimens are from two to twelve inches in diameter—each the skeleton of a single polyp.

FIG. 731.



Fungoid Coral.

Hundreds of islands and reefs are made of coral—the skeletons of Polyps.

These islands and reefs are most abundant in the Pacific and Indian Oceans; but the islands which skirt the coast of Florida—the Keys—are also of coral formation; and, according to Agassiz, a large part of Florida itself is composed of coral. Some reefs are small, and have made only a little progress upward towards the surface of the water; others are miles in length and breadth, and come so near the surface that it is dangerous for vessels to sail over them; and others rise above the surface of the water, forming islands which, in some cases, are covered with coral sand, and in others with a more or less luxuriant growth of tropical vegetation.

Coral reefs stretch north and south near New Caledonia for the distance of four hundred miles; and along the north-eastern coast of Australia for a thousand miles.

When a reef or bank of coral is near the shore, it is called a *Fringing Reef;* when at a distance from the shore, a *Barrier Reef;* and when it surrounds a body of water, as is often the case in the Pacific, an *Atoll* or *Coral Island.*

The corals which form the principal part of the reefs and islands are *Madrepores, Porites, Mæandrinas,* and *Astræas;* and to these we must add the Pocillopores (Fig. 724) and Millepores (mentioned on page 465).

The frailer forms, as Sea-fans and other gorgonians, and various other delicate kinds, adorn the reef, but contribute comparatively little to its growth.

From what has already been said, it will be understood that coral reefs and coral islands are not something which the coral animals build, as a mechanic builds a house, or as a bee or wasp builds her nest or comb; but that the reefs and islands are made of the hard parts or skeletons of polyps and other marine forms that lived and died where the reef or island now stands.

Only about an inch of a growing coral mass or reef is alive; all the rest within is dead; death goes on below as fast as growth goes on above. When the reef at last grows up to the surface of the water, the polyps die; for they cannot live out of water. The winds and waves do the rest; they break fragments from the sides of the reef and pile them nearer the center; they bring sea-weeds and other floating materials, and cast them over the whole; plants at length spring up; and in the course of years, the island—except its broad beaches of coral sand—is clothed with verdure; and man, perhaps, comes there and makes his home.

But a history of the Polyps would be incomplete if we should not mention their connection with some of the rocks of the globe—the limestones. Corals abound in the rocks of almost every country, and upon the mountains as well as in the low lands; and vast reefs are found hundreds of miles from any ocean. Coral reefs and coral islands have essentially the same composition as limestone or marble, being composed mainly of carbonate of lime.

From these facts, and many others, geologists believe that a large part of the limestones of the globe are made out of the coral reefs that were formed in the old oceans, which long ages ago covered the countries where limestones are now found.

If this be true, many of the rocks which underlie vast countries, the marble temples and palaces of the East, the marble monuments and public buildings of our own country, the mortar upon the walls and ceilings of our houses, and the marble tables and mantels so highly prized —all have come from the skeletons of these and other low animals of the sea.

And perhaps it is not too much to say that their skeletons have furnished even the blocks of marble which the sculptor chisels, and that thus the polyps are connected with the highest department of culture and of art in which the mind and hand of man can engage.

PRINCIPAL TOPICS CONSIDERED IN CHAPTER V.

SECTION I.

The Radiates considered as a Branch.——The arrangement of their parts, etc.——Classification.

SECTION II.

SUB-SECTION I.

The Echinoderms considered as a Class.——Meaning of the name.——Classification.

SUB-SECTION II.

The Holothurioidea as an Order.——Plates in the skin.——Size.

SUB-SECTION III.

The Echinoidea or Sea-urchins as an Order.——Ambulacral and interambulacral plates.——Eyes.——Dental apparatus.——Regular and Irregular Echinoids.

SUB-SECTION IV.

The Asterioidea considered as an Order.——Their form, structure, food, etc.

SUB-SECTION V.

The Ophiurioidea considered as an Order.——Astrophyton.

SUB-SECTION VI.

The Crinoidea.——The living and the fossil kinds.

SECTION III.

SUB-SECTION I.

The Acalephs considered as a Class.——Meaning of the name.——Size.——Food. ——Classification.

SUB-SECTION II.

The Ctenophoræ considered as an Order.——Their form.——Structure, etc.

SUB-SECTION III.

The Discophoræ considered as an Order.——Their form, structure, development, etc.

SUB-SECTION IV.

The Hydroidea considered as an Order.——Their forms, modes of development, etc.——"Fresh-water Polyps."

SECTION IV.

SUB-SECTION I.

The Polypi considered as a Class.——Their form and general structure.——Lassos. ——Food.——Modes of increase.——Coral.——Classification.

SUB-SECTION II.

The Alcyonaria considered as an Order.——Leading forms.——Spicules.

SUB-SECTION III.

The Actinaria considered as an Order.——General absence of hard parts.——The kinds which live in communities.

SUB SECTION IV.

The Madreporaria considered as an Order.——The Principal forms.——Coral Reefs and Coral Islands.——Coral and Limestone.

CHAPTER VI.

THE BRANCH OF PROTOZOA OR PROTOZOANS.

SECTION I.

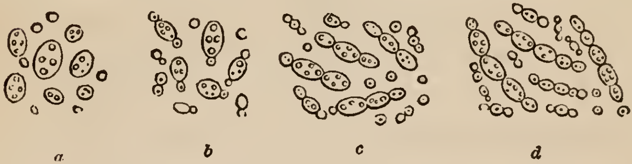
THE PROTOZOA CONSIDERED AS A BRANCH.

As already stated on page 5, there are vast numbers of beings which are so simple in their form and structure, that naturalists are in doubt, in many cases, whether to call them Plants, or Animals.

In most cases they have neither mouth nor stomach; and with comparatively few exceptions, they are exceedingly minute, and mostly microscopic. Many of them are so small that they can be studied only by the most skillful observers, aided by the most powerful microscopes.

In a vast number of cases they are apparently no more, and in many cases even less complicated in their structure than this little plant which we call yeast, being mere particles of mucous-like matter (sarcode or protoplasm).

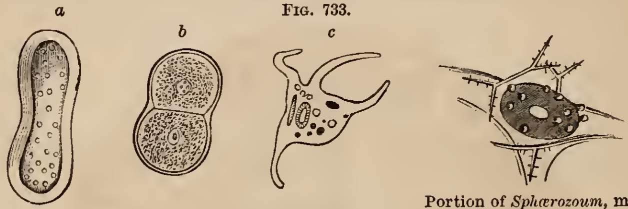
Fig. 732.



Yeast-plant (*Torula cerevisiæ*) as developed during fermentation.
a, *b*, *c*, *d*, successive stages of cell multiplication.

The name Protozoa comes from the Greek *protos*, first, in the sense of simplest, and *zoon*, an animal.

Fig. 733.



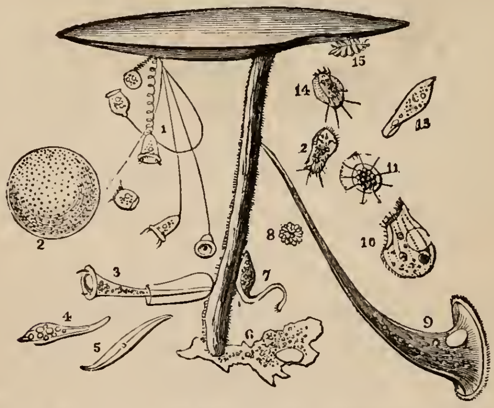
Portion of *Sphærozoum*, more highly magnified.

Protozoans.

a, *Sphærozoum*; *b*, *Gregarina*; *c*, *Amœba*; all magnified.

The Protozoans are probably more numerous than all other animals of the globe. They abound in every ditch and pool, every stream, pond, and lake, and in almost every part of the ocean. And there is hardly a drop of water that is not inhabited by some of them. They were also abundant in the past geologic ages. Their skeletons or hard parts abound in the rocks in many places; and in some countries rocky strata hundreds of feet in thickness

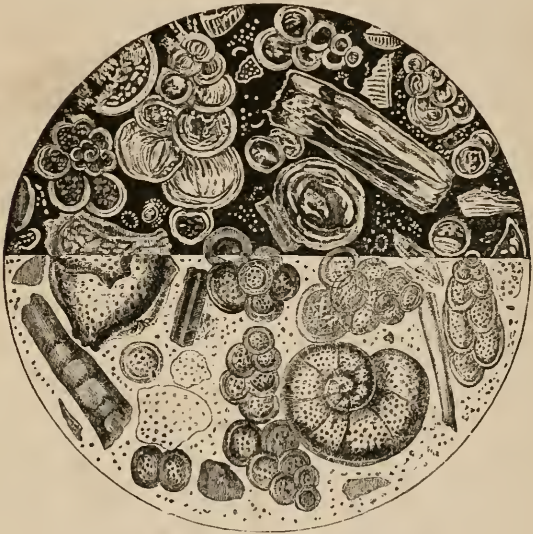
Fig. 734.



Protozoans around an aquatic plant—a leaf of Duckweed. See page 9.

are wholly made up of their remains. The vast chalk beds of Europe and of other countries are almost wholly composed of the skeletons of microscopic protozoans—mainly Rhizopods. And, according to the estimate of Ehrenberg, the great Prussian microscopist, *there are* 1,000,000 *of these organisms in a cubic inch of chalk!*

FIG. 735.



Microscopic Protozoa in Chalk.

The Protozoa have been extensively studied and variously classified. Until comparatively recent times they were usually regarded as forming three great groups—Infusoria, Rhizopoda, and Spongida; but naturalists now recognize six or more great divisions.

I. SPONGIDA OR PORIFERA: as the Marine and the Fresh-water Sponges.
II. INFUSORIA or Ciliata; as *Vorticella, Stentor, Paramecium,* etc.
III. FLAGELLATA (including Noctilucæ?); as the Monads.

IV. RHIZOPODA (including Radiolaria and Foraminifera); as *Polycistina, Sphærozoum, Polystomella, Nummulina, Globigerina, Cornuspira, Gromia, Difflugia, Arcella, Actinophrys, Amœba,* etc.

V. GREGARINIDA; as parasitic protozoans.

VI. MONERA; as *Bathybius, Protomonas,* etc.

SECTION II.

THE SPONGIDA OR SPONGES.

The Sponges were formerly regarded by many naturalists as belonging to the vegetable kingdom. They are now regarded as compound animals by all, and by many as being even higher than the Protozoa, having close analogies with the Radiates.*

The living Sponge is composed of an exceedingly soft, filmy substance, and hard parts which this substance secretes. Water is admitted through numerous minute pores, which open into a system of branching canals, and these lead into the large pores which we see upon the surface, and through which the water and other bodies are discharged (Fig. 740). The water is kept in motion by ciliated cells. Sponges increase by eggs and sperm cells.

Sponges are common in ponds and lakes, as well as in nearly all parts of the sea; and their forms are exceedingly various and often extremely beautiful. Some cover the rocks like a carpet of mosses; others grow in massive clusters; others branch like trees and shrubs; and others still take the form of the most elegant cups, goblets, and vases.

As just indicated, Sponges secrete hard parts. They form the well-known "sponge" of commerce. Some kinds (Fig. 737) secrete a siliceous skeleton; and most if not all kinds secrete and thus form siliceous spicules (Figs. 736, 738).

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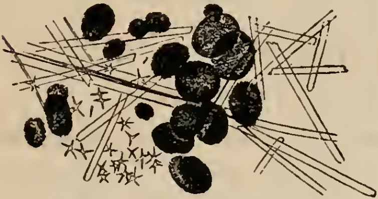
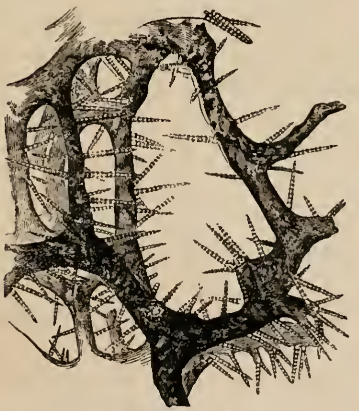
* See Lieberkühn, Carter, Clark, Packard (American Naturalist, Vol. IX., No. 2), etc.

FIG. 736.



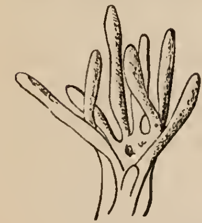
Sponge—showing Siliceous Spicules. Much magnified.

FIG. 738.



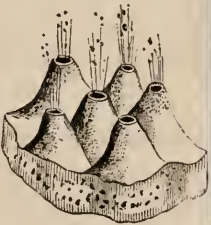
Sponge—showing Spicules. Much magnified

FIG. 739.



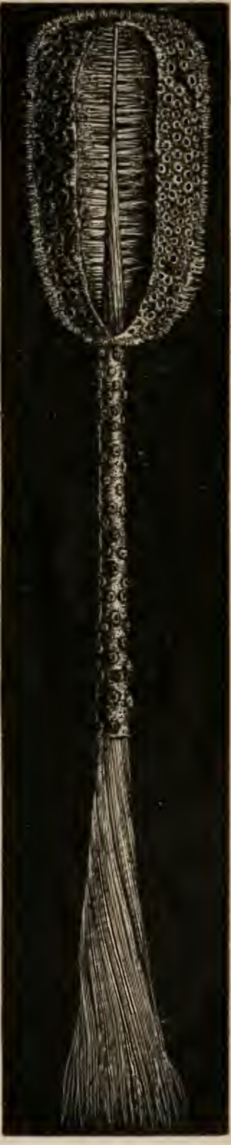
Sponge.

FIG. 740.



Living Sponge.

FIG. 737.

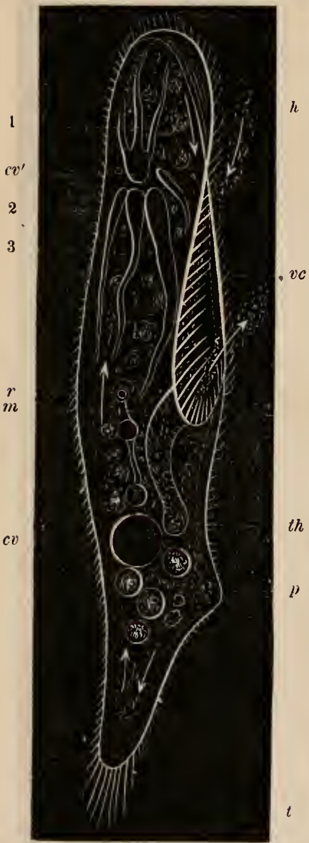


Sponge—*Hyalonema Sieboldii*—one-third natural size. After Schulze.

SECTION III.

THE INFUSORIA OR CILIATA.

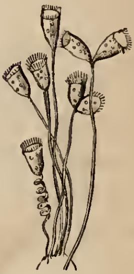
FIG. 741.



Paramecium caudatum, Ehrenberg —Magnified.

h, head; *t*, tail; *m*, mouth; *th*, throat; *p*, posterior opening of the digestive cavity; *cv′*, *cv*, anterior and posterior contractile vesicles. 1, 2, 3, radiating canals of *cv′*; *r*, reproductive organ; *vc*, vibrating cilia.

FIG. 742.



Vorticella.

THE Infusoria or Ciliata are now regarded as the highest representatives of the Protozoa, excepting only the sponges.

Two or three forms will give the student a general idea of this group. Those called Vorticellæ, or the Bell-shaped animalcules (Fig. 742) are common on aquatic plants. They are in the form of ciliated bells mounted on long stalks. They are visible to the naked eye.

The Trumpet animalcules (*Stentor polymorphus*, Ehren., Fig. 739) secretes a sort of tube into which it contracts when disturbed—which Dr. Packard calls an anticipation in nature of the worm in its tube.

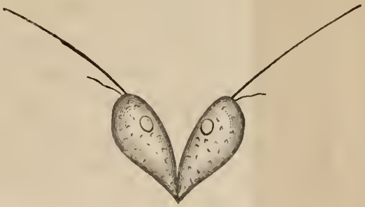
One of the most simple and most common forms of Infusoria is Paramecium (Fig. 741, from Clark's "Mind in Nature"), which is hardly more than a particle of protoplasm, representing, perhaps, only a single cell. Yet it is regarded as having a so-called mouth, digestive cavity, etc.

SECTION IV.

THE FLAGELLATA OR MONADS.

The Flagellata or Monads are exceedingly minute protozoa, having oval bodies, with a nucleus and a contractile vesicle, and one or two long whip-like cilia. It is on account of the last-named fact that they have been called Flagellata.

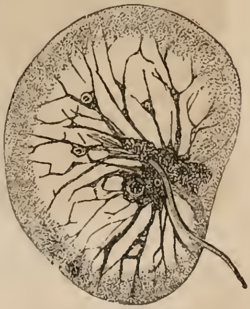
Fig. 743.



Monads (*Urella*), magnified 1,000 diameters. From *Am. Naturalist.*

Not far removed from the Monads—even if they do not belong with them—are the Noctilucæ (Fig. 744), very minute organisms which abound on the surface of the sea, and which are remarkable for their phosphorescence. They have a somewhat spherical and jelly-like body, with a groove on one side, from which there extends a thread-like locomotive organ.

Fig. 744.



Noctiluca miliaris—Magnified.

SECTION V.

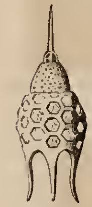
THE RHIZOPODA OR RHIZOPODS.

The Rhizopods or "Root-footed" protozoa are so called from the root-like filaments which they extend from the main mass of the body (from the Gr. *rhiza*, a root, and *pous*, a foot). These root-like projections are also called pseudopodia or false feet. Many rhizopods increase by self-division.

Those called Radiolaria have a highly developed siliceous or glass-like shell. They multiply by the production of bodies called zoöspores.

The Radiolarian shells are minute, and, as the name implies, are radiate in their structure. They are remarkable in the variety of their forms; and they are curiously and beautifully ornamented. The most remarkable forms are called Polycistines. They abound in the sea, and in many places—Island of Barbadoes, etc.,—they make up a large part of extensive rock formations.

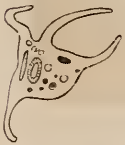
Fig. 745.



Polycistine—*Podocyrtis Schomburgkii.*

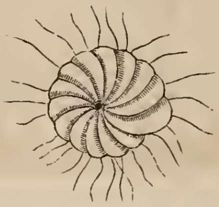
The Foraminifera are rhizopods which, in most cases, have a shell composed of many

Fig. 746.



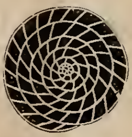
Naked Rhizopod, *Amœba radiosa.*

Fig. 747.



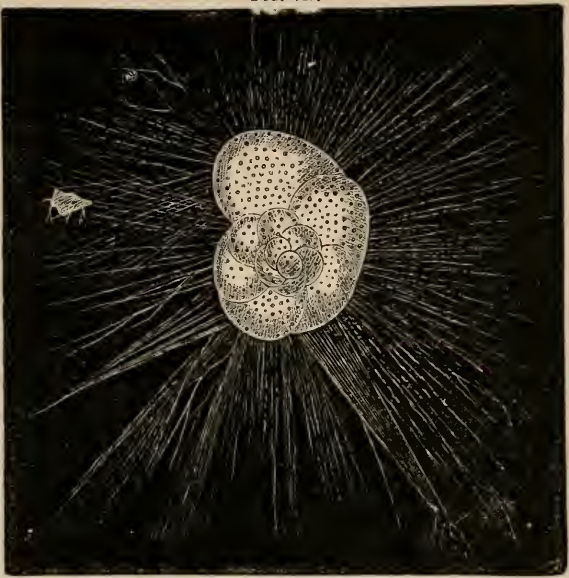
Foraminifer, *Polystomella crispa.*

Fig. 748.



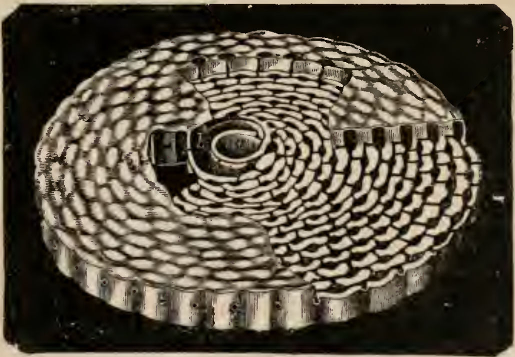
Foraminifer, *Nummulites lenticularis.* A Section.

FIG. 749.



A Foraminifer, *Rosalina ornata*, with its "false feet," or pseudopodia extended. Magnified.

FIG. 750.



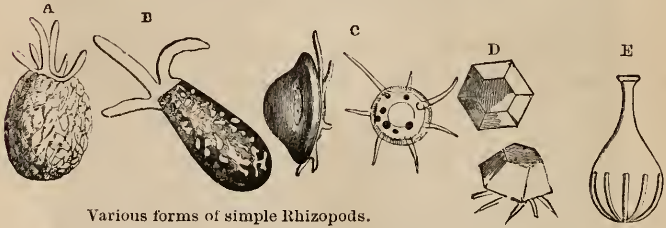
Shell or hard parts of a Foraminifer, *Orbitolites complanatus*, partly laid open to show its structure.

a, central cell; *b*, circumambient cell, surrounded by concentric zones of cells connected with each other by radiating passages. Magnified.

chambers, and in the shell are many pores through which the pseudopodia are extended (747, 749).

Some forms, however, which are closely allied to the Foraminifera, even if they are not included in the same group, have only one chamber in the shell. Such are *Difflugia*, *Arcella*, etc. (Fig. 751).

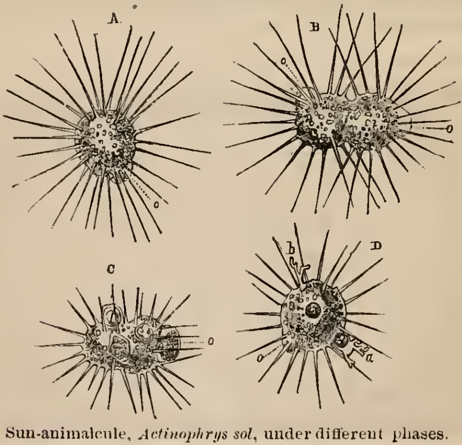
FIG. 751.



Various forms of simple Rhizopods.

A, *Difflugia proteiformis ;* B, *D. oblonga ;* C, *Arcella acuminata ;* D, *A. dentata;* E, *Lagena striata (fossil).* Magnified.

FIG. 752.



Sun-animalcule, *Actinophrys sol*, under different phases.
A, the ordinary form.—Magnified.

Still other forms, as *Amœba* (Fig. 746), and *Actino-*

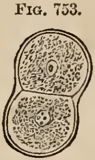
phrys (Fig. 752), are soft particles of protoplasm, without any shelly covering. The Amœba has a nucleus, and the body exhibits a more or less clear outside layer and an inner granular portion.

SECTION VI.

THE GREGARINIDA.

These are parasitic protozoa, which are more or less worm-like in form. Until the Moners were discovered, they were regarded as the lowest animals. They live in insects, crustaceans, and worms; and are microscopic in size. One species, however, attains the length of over half-an-inch.

Fig. 753.



Gregarina sipunculi.—Magnified.

SECTION VII.

THE MONERA OR MONERS.

The beings called Moners are so simple in their structure—or rather they are so entirely destitute of structure—that it is doubtful whether they are plants or animals. They are *merely structureless living albuminous jelly*, far simpler than even the Amœba.

The simplest known form of life is a moner, called *Bathybius*, discovered by Professor Wyville Thompson, at a depth of 2,435 fathoms, in the Bay of Biscay.

CHAPTER VII.

CONCLUDING REMARKS.

In the preceding chapters we have obtained a glimpse—and only a glimpse—of the Animal Kingdom as it now appears on the surface of the globe.

But the animals of the present, vast as are their numbers, are but a handful compared to those that have occupied the surface of the earth in past geologic ages, and that are now known only by their remains, which fill the rocks in many countries to the depth of six or eight miles or more.

Nature has embalmed these races, and handed them down to us so perfectly preserved, that we are able to get at least a faint view of the phases of life during all the past ages of the world. And it is a fact of the highest significance, that the animals of the past, and those of the present, are built according to the same great plan. Protozoans, Radiates, Mollusks, Articulates, and Vertebrates are all the types under which animal life has been exhibited upon the earth.

When we consider the branches, the classes, the orders, the families, the genera, the vast number of living, and perhaps the much greater number of extinct species, and then consider that each species is represented in many cases by millions of individuals, and that probably no two individuals, even of the same species, are exactly alike in every particular, and yet that each one of all these countless millions bears within itself the stamp of a Protozoan, or a Radiate, or a Mollusk, or an Articulate, or a Vertebrate, so clearly, that by patient study, the student of nature is able to refer every one of to-day, and of by-gone ages, to its appropriate type—we are impressed with the great truth, that in the Animal Kingdom—and it is so in all nature—there is the greatest possible diversity, and that in this diversity there is perfect unity; and hence we are forced to believe that all the animals of the past, and all those of the present, have appeared in accordance with a plan wrought out in the Divine Mind before the foundation of the world.

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